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SITE ASSESSMENT REPORT / CORRECTIVE ACTION PLAN
FUEL HYDRANT SYSTEM (SITE SS-41)
PROJECT DKFX937081R1
CHARLESTON AIR FORCE BASE, SOUTH CAROLINA

Prepared For:

AIR MOBILITY COMMAND
ENVIRONMENTAL A/E SERVICES PROGRAM
CONTRACT F11623-94-D-0024
DELIVERY ORDER No. 5000

Prepared By:

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CARY, NORTH CAROLINA

MAY 1996

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1. INTRODUCTION

1.1 PURPOSE AND SCOPE OF REPORT

Parsons Engineering Science, Inc. (Parsons ES) under contract to the Air Mobility Command (AMC), has conducted an investigation within a portion of Site SS-41 Fuel Hydrant System. The investigation was limited to the vicinity of the existing and former fuel hydrant system pumping stations at Buildings 99, 95, and 93 on the east side of the flightline drainage ditch that parallels Taxiway #4 and the aircraft apron. Limited investigations were performed on those portions of the fuel hydrant system located on the west side of the drainage ditch due to ongoing Navy fuel hydrant system and aircraft apron renovation projects.

The northern boundary of the study area extends to the point where the primary 8-inch fuel delivery pipeline turns and crosses the flightline ditch enroute from the POL Fuel Depot. To the south, the study area boundary extends to East Taxiway #6. This taxiway separates fuel pumping station #1 (Building 99) from the flightline ditch fuel recovery system project area. Toward the west, the study area is bounded by the flightline drainage ditch that parallels the aircraft apron. The majority of the investigation activities were performed on the east side of this ditch (see Figure 2.1).

The objectives of the investigation at Site SS-41 Fuel Hydrant System are to:

- Determine the nature and extent of soil and groundwater contamination at the site;
- Evaluate surface water and sediment contamination which may have resulted from contaminant migration through the shallow groundwater at the site;
- Characterize the hydrogeologic framework of the site;
- Evaluate the potential effects of site contamination on human health and the environment through a risk evaluation; and
- Identify and evaluate potential corrective action alternatives for remediation of the site.

The site investigation was performed in accordance with RCRA, and additional guidance from the South Carolina Department of Health and Environmental Control (SCDHEC). Results of previous investigations performed by others are incorporated into this report where appropriate. This report has been prepared under guidance from SCDHEC, specifically the Risk-Based Corrective Action for Petroleum Releases (SCDHEC, June 1995) or RBCA guidance. For chemicals of concern (COCs) that were detected in media at the site during the investigation that are not addressed by the RBCA guidance, the EPA Region IV risk screening method was used to evaluate potential risks at the site.

1.2 SITE BACKGROUND

Charleston AFB is located in Charleston County, South Carolina. The base is located approximately 10 miles northwest of the City of Charleston, as shown on the regional map

in Figure 1.1. The base encompasses 3,731 acres, with an approximate population of 8,500.

The base was activated as an Army Air Base four days after the Japanese attack on Pearl Harbor. The Base was initially established for defense and training of bomber forces during World War II. After World War II ended, the base closed and the property was returned to the City of Charleston. While in possession of the property from 1946 to 1952, the City periodically leased portions of land for use by private businesses. In 1947 a new municipal airport facility was completed.

The base was reactivated during the Korean War as part of the Military Air Transport Service (MATS). In 1952 the Air Force began constructing facilities west of the existing facilities. The new facilities were constructed to support a troop carrier operation. The MATS became the Military Airlift Command (MAC) in 1966, and was changed to Air Mobility Command (AMC) in 1992. The base is currently under the AMC. The runways are part of Charleston AFB and are shared by the Air Force and the Charleston County Aviation Authority under a joint-use agreement. Figure 1.2 shows a facility site plan of the base and commercial airport.

The 437th Airlift Wing is the current host command at Charleston AFB. The primary mission of the 437th is to maintain immediate airlift capability to deliver and sustain air and combat forces to combat locations. During peacetime, operations include resupply of overseas American embassies, military installations, and supply of aid to natural disaster areas. The 437th also provides the support functions to maintain the Charleston AFB facilities.

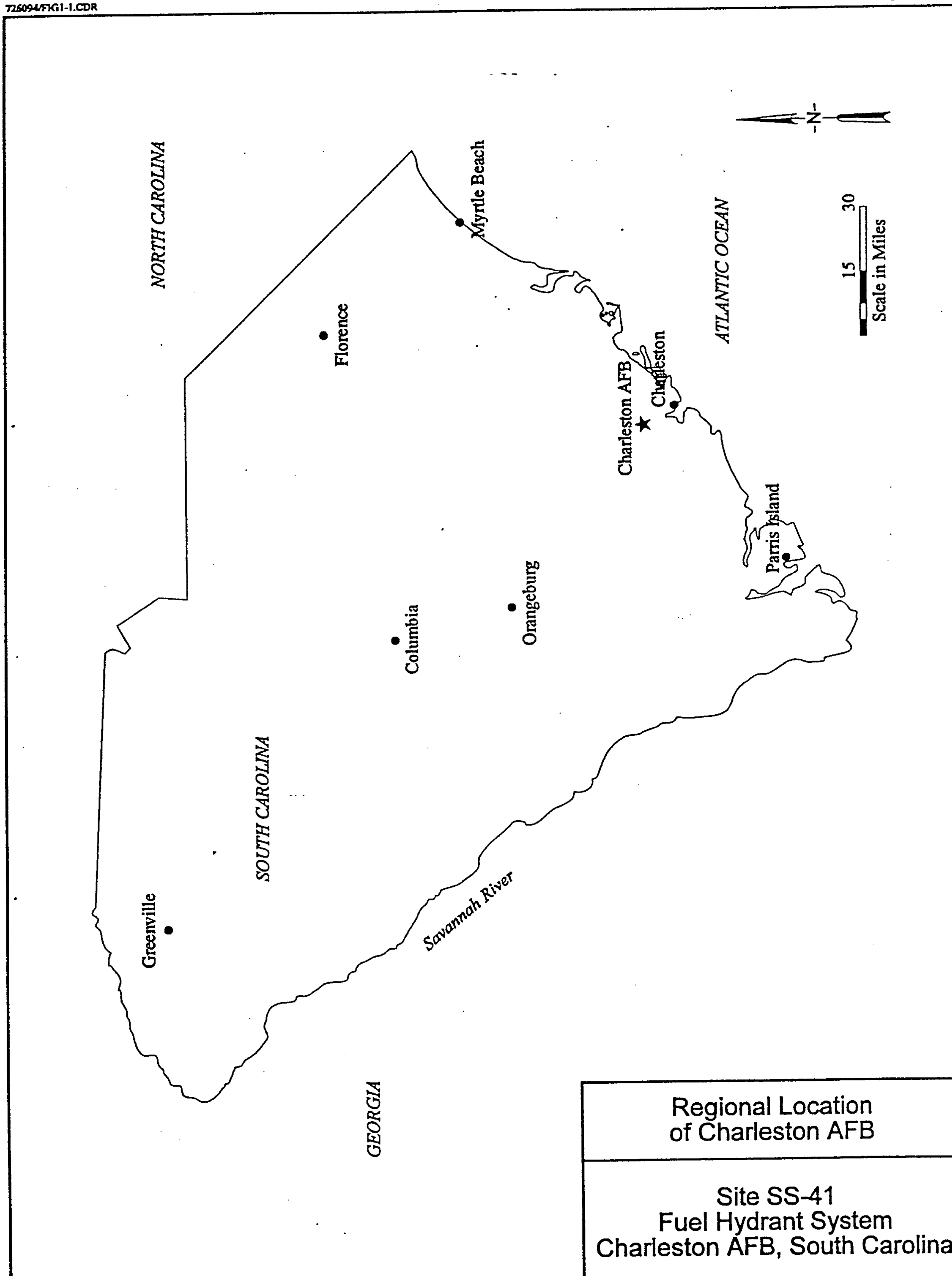
1.3 SITE DESCRIPTION

Jet fuel is received at the Charleston AFB Petroleum, Oil, and Lubricant (POL) Bulk Fuel Storage Depot (POL Fuel Depot) via an underground pipeline from an off-base source at the Defense Fuel Supply Point. Most of the jet fuel used for aircraft refueling is distributed through the Base fuel hydrant system. The Charleston AFB fuel hydrant system begins at the POL Fuel Depot on the northwest side of the base and consists of a network of pipelines and fuel pumping stations that transfer jet fuel from the POL Fuel Depot to various fueling stations on the aircraft maintenance apron. The fuel hydrant system includes three flightline fuel pumping stations, a primary 8-inch fuel transfer pipe connecting the POL Fuel Depot to the flightline fuel pumping stations, a network of piping headers and lateral fuel lines that transfer jet fuel from the three pumping stations to various fueling points on the aircraft maintenance apron, and ancillary drains, filters, waste fuel underground storage tanks (USTs) and valve pits. The base has designated the entire fuel hydrant system as IRP Site SS-41. The liquid fuels pipeline and fuel hydrant system locations are shown in Figure 1.3.

Existing or former fuel pumping stations included in the fuel hydrant system include those located at Building 99 (pumping station #1), Building 95 (pumping station #2), and Building 93 (former pumping station #3). Each of the fuel pumping stations uses a system of six 50,000-gallon USTs for interim storage and transfer of jet fuel between the POL Fuel Depot and the aircraft parking apron fueling points. The base-wide comprehensive RCRA Facility Investigation (RFI) Work Plan developed by Halliburton NUS Corporation

726094/FIG1-1.CDR

Figure 1.1

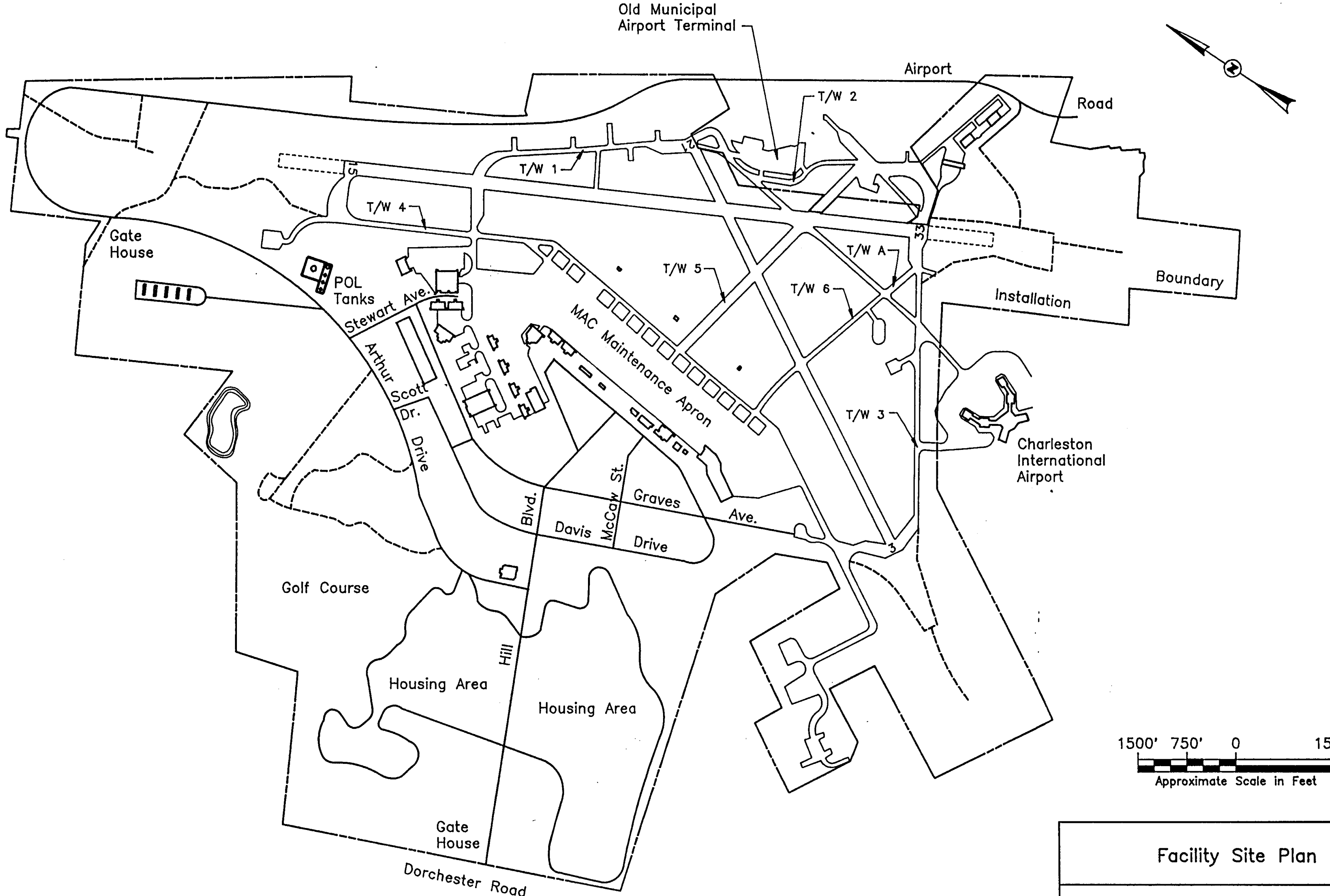


Regional Location of Charleston AFB

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

Parsons Engineering Science, Inc.

Figure 1.2



Map Sources:
1) Charleston AFB (1979)
2) Engineering–Science, Inc. (1983)

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Facility Site Plan

Site SS–41
Fuel Hydrant System
Charleston AFB, South Carolina

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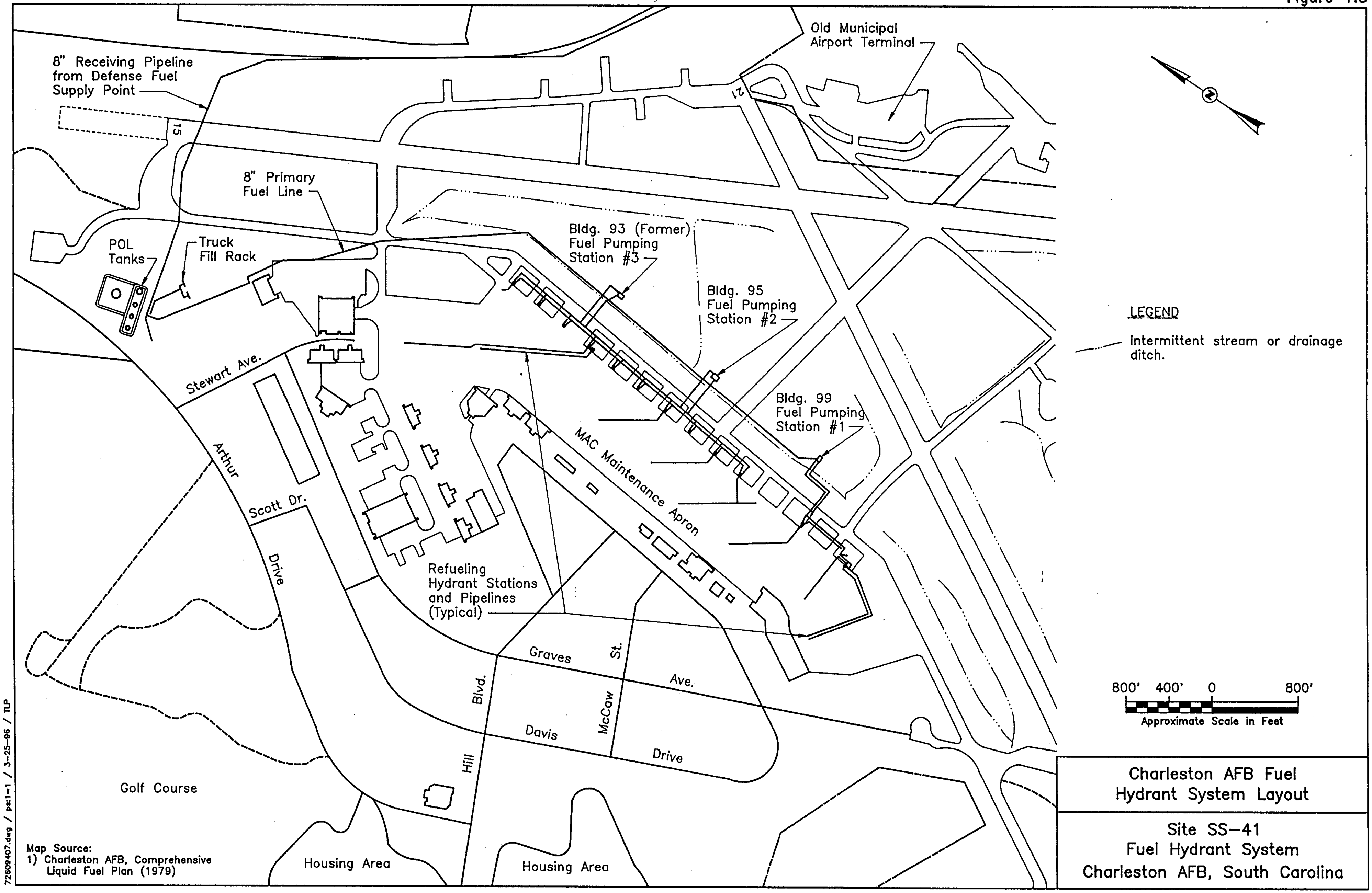
Figure 1.3



PARSONS ENGINEERING SCIENCE, INC.

(July 1993) identifies the fuel pumping station at former Building 93 (labeled as Building 97 in the 1993 RFI Work Plan) as Solid Waste Management Unit (SWMU) 146, and Building 99 as Area of Concern (AOC) B. Fuel pumping station #2 (Building 95) is not addressed in the base-wide RFI Work Plan. The Building 95 fuel pumping station was included as part of the investigation by Parsons ES at Site SS-41. A brief discussion of these areas is provided in the following sections.

The base fuel hydrant system, aircraft parking apron, and portions of apron access taxiway #4 are currently being renovated and expanded under a Navy Military Construction (MILCON) project. The new fuel hydrant system includes two above-ground fuel storage tanks and a new fuel pumping station on the flightline area east of the aircraft apron. The fuel pumping station and six USTs previously located at Building 93 were removed from service and demolished from July through October 1993 as part of this renovation project. An unknown quantity of fuel-contaminated soil was excavated and transported off-site during the UST removals at Building 93.

1.4 SITE HISTORY

1.4.1 Building 99 (Fuel Pumping Station #1)

A surface spill of approximately 500-800 gallons of JP-4 jet fuel occurred at Building 99 fuel pumping station in July 1989. The Air Force collected initial soil samples for laboratory analyses at four soil boring locations in August 1989. The analytical results indicated that soils were impacted by fuel hydrocarbon constituents.

A preliminary non-Installation Restoration Program (IRP) site assessment was performed in June 1990 by General Engineering Laboratories (GEL), who installed four groundwater monitoring wells, three temporary piezometers, and twenty-four shallow soil borings. Soils from the borings were screened in the field for organic vapors and three soil samples from one borehole were submitted for laboratory analyses. Groundwater contamination was detected in one monitoring well during this assessment (GEL, 1990).

A subsequent remedial investigation was performed at Building 99 by Soil and Material Engineers, Inc. (S&ME; formerly Westinghouse) in November 1991. The S&ME remedial investigation was initiated with a groundwater contaminant screening survey using retractable sample probes and a field gas chromatograph (GC). The remaining scope of the investigation included installation and sampling of three additional groundwater monitoring wells (two shallow, one deep), collection and analysis of four sediment and two surface water samples, and aquifer slug testing. The S&ME investigation successfully completed the delineation of fuel hydrocarbon contamination in groundwater around Building 99. These results are found in the S&ME Remedial Investigation Report (March 22, 1993). Six monitoring wells currently exist around the fuel pumping station at Building 99. Groundwater from these wells is sampled quarterly and analyzed for benzene, toluene, and ethylbenzene (BTEX); methyl tert-butyl ether (MTBE); naphthalene; and lead.

1.4.2 Building 95 (Fuel Pumping Station #2)

The Building 95 fuel pumping station has not been investigated under the IRP program and it was not identified in the comprehensive RFI Work Plan developed by Halliburton NUS Corporation. The Building 95 fuel pumping station was included as part of the Parsons ES investigation of Site SS-41. The fuel transfer pipeline connecting this pumping station to the adjacent two pumping stations were included in the investigation. A new above-ground jet fuel storage tank system is currently being constructed adjacent to this fuel pumping station as part of the Navy MILCON project.

1.4.3 Former Building 93 (Fuel Pumping Station #3)

Geotechnical studies and environmental soil sampling were conducted by Westinghouse Environmental and Geotechnical Services, Inc. (Westinghouse) during August and September 1991 to support the Navy MILCON fuel hydrant system/aircraft apron renovation project. The scope of the Westinghouse investigation included 71 drilled geotechnical borings and 10 hand augered borings installed around the aircraft apron, Taxiway #4, the POL Fuel Depot, and portions of the fuel hydrant system planned for demolition and/or renovation. Soil samples were collected from 53 of the borings for environmental sampling purposes. Eighteen of the environmental soil samples were collected in the vicinity of the Building 93 fuel pumping station. The soil samples were collected at the water table interface in each borehole. Soil samples were field-screened for organic vapors with a photoionization detector (PID) and were then submitted for laboratory analysis for BTEX. BTEX constituents were detected in nine soil samples collected around Building 93. Fuel-related contamination was identified in soils on both sides of the flightline ditch in this area. No groundwater monitoring wells were installed during the investigation (Westinghouse, 1991).

Additional non-IRP soil sampling was performed at Building 93 fuel pumping station in September 1993 by Coastal Engineering and Testing, Inc. Soil samples were collected prior to and during the UST removals as part of the Navy fuel hydrant system renovation project. Soil borings were advanced around and beneath the USTs and associated piping in a grid pattern. Soil samples were analyzed for total petroleum hydrocarbons (TPH), BTEX, and naphthalene. Additional analyses were performed on several of the samples for metals and jet fuel-fraction hydrocarbons. Petroleum-related constituents were detected in the majority of these samples (Charleston AFB, 1993).

After the Building 93 pumping station was demolished, a bioventing treatability pilot study was initiated at the site by Parsons ES under contract to the Air Force Center for Environmental Excellence (AFCEE). A limited soil gas survey was performed to identify areas with fuel-contaminated, oxygen-depleted soils suitable for the bioventing treatment. Two air injection ventilation wells and four permanent vapor monitoring points were installed near the former UST locations as part of the study. Three soil boring samples were collected in unsaturated soils of the study area for BTEX and total recoverable petroleum hydrocarbons (TRPH) analyses. Three soil gas samples were collected from the vapor monitoring points for BTEX and total volatile hydrocarbons (TVH) analyses. Each of these environmental samples showed impact by petroleum-related compounds.

The pilot-scale bioventing system began operating in July 1994, and ran for approximately one year.

In May 1994, Halliburton NUS Corporation conducted a limited investigation in the vicinity of former Building 93 pumping station according to the comprehensive base-wide RFI Work Plan. Three soil borings were advanced and sampled in the locations where soil contamination was detected during the Westinghouse investigation. Soil samples were analyzed for target volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, and TPH. Additionally, two surface water and two sediment samples were collected from the flightline ditch and analyzed for the same parameters.

1.5 ENVIRONMENTAL SETTING

This section summarizes pertinent environmental conditions at Charleston AFB which affect the of contaminant distribution and migration evaluated in this report. The evaluation of potential risks and corrective action alternatives at Site SS-41 is highly dependent upon the current environmental setting and the projected future uses for the land, surface water, and groundwater at the base.

1.5.1 Physiography/Topography

Charleston Air Force base encompasses a total of 3,731 acres and is located in the lower part of the Atlantic Coastal Plain physiographic province between the Ashley and Cooper Rivers (see Figure 1.4). The designated study area includes approximately 90 acres of this total.

The base is characterized by relatively flat relief. Elevations range from 0 feet above sea level along the Ashley River to the west of the base and Goose Creek to the east, to 40 feet on the highest parts of the base (the flight line area). The majority of Site SS-41 lies above the 25 foot elevation, with the exception of ditches, creeks, and isolated depressions.

1.5.2 Climate

The climate of the Charleston area is subtropical and is characterized by warm, humid summers and short, mild winters. Hurricanes periodically occur in the area and exert an important climatic and physical influence on ecological systems on the base as well. Hurricane Hugo significantly affected the quality of terrestrial habitats on the base, and it has been estimated that this single storm event virtually eliminated any foraging habitat for the red cockaded woodpecker (Southeastern Surveying, Inc. and Newkirk Consultants, Inc., 1991).

1.5.3 Land Use

The vicinity of Site SS-41 is used solely for Air Force and Airport operations. Site SS-41 is located along the 8-inch fuel pipeline as described in Section 1.3. The site is bordered by the aircraft maintenance apron, several concrete taxiways, and the two aircraft runways (see Figure 1.2). The land surface surrounding the site is relatively flat, with the greatest topographic relief present at the flightline drainage ditch. There are no

current plans to significantly change land use on the base or Airport property in the foreseeable future.

The area surrounding Site SS-41 for a one-mile radius is delineated on Figure 1.4. The majority of this area is within the AFB and Airport property and is used for industrial purposes (AFB and Airport operations). In the northeast corner of the surrounding area, some residential and light industrial properties are present. In part of the southern section of the area, land outside the AFB and Airport property is shown on the U.S.G.S. topographic map as a strip mine, probably from phosphate mining operations. Two base housing areas are located within the one-mile radius, one in the northwest corner of the area (base trailer park) and the other in the west-southwest portion of the area.

All of the terrestrial habitats present within the designated study area have been significantly disturbed by previous land management practices. The majority of upland habitats within the designated study area consist of isolated disturbed pine forests, most of which are located in urbanized areas and which have been maintained by mowing. Some low value early successional woody vegetation also exists within the flightline ditch system. There is virtually no natural undisturbed upland habitat within the designated study area.

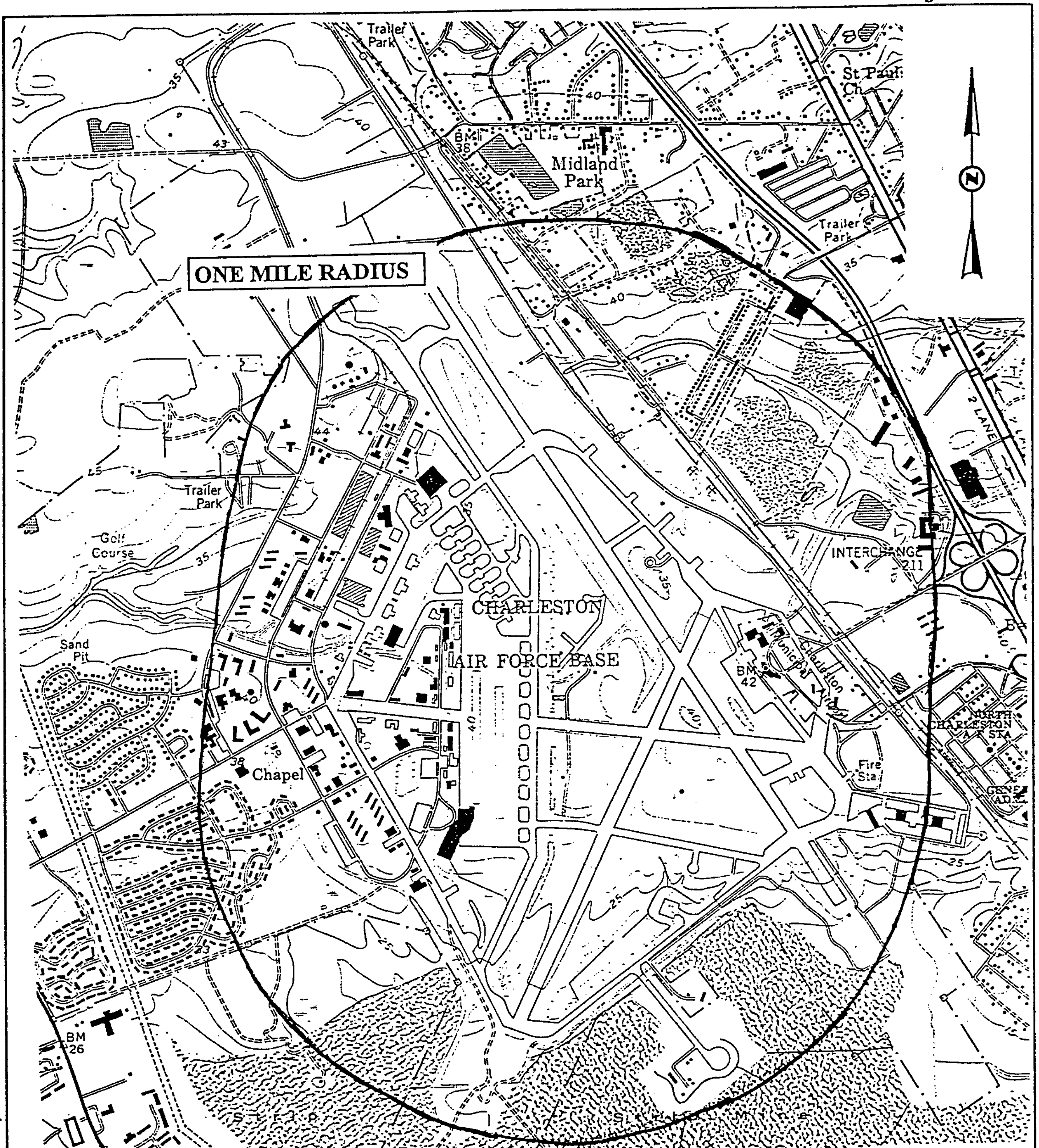
1.5.4 Surface Water

Major surface water features in the vicinity of Charleston AFB are shown on Figure 1.5. Surface water in the area surrounding Site SS-41 drains into the flightline drainage ditch which discharges into Runway Creek which flows from the southern boundary of the base into the Ashley River (see Figure 1.5). The portion of the Ashley River into which Runway Creek discharges is affected by salt-water encroachment during high tides (Engineering-Science, 1983).

Surface water in the vicinity of Charleston AFB is used primarily for recreational purposes and as a water supply. Charleston AFB and the Charleston area obtain drinking water from the Charleston Commission of Public Works. The water supply system contains three water intakes that are on the Edisto River (approximately 25 miles northwest of Charleston AFB), on Goose Creek Reservoir (approximately 2 miles northeast of Charleston AFB, see Figure 1.7), and on Foster Creek (approximately 8 miles north of Charleston AFB). The water is transmitted from the Edisto River and Foster Creek through unlined tunnels excavated within the Cooper Formation. The average daily use of surface water within the central system is 80 million gallons per day and, in 1975, the estimated maximum daily demand of water on the base was 1.88 million gallons per day. The average maximum daily demand of water during the first 3 months of 1983 was 1.85 million gallons per day (Engineering-Science, 1983).

The primary surface water resources on the base includes streams, creeks, and ditches associated with three drainages - (1) Golf Course Creek, which discharges to the west into Popperdam Creek, a tributary of the Ashley River; (2) Runway Creek, located near runway 03/21, which discharges to Filbin Creek to the south and ultimately to the Ashley River; and (3) an unnamed tributary of Turkey Creek near runway 15/33 which discharges to the east into Goose Creek. Surface water east of runway 15/33 generally flows into creek to the east and ultimately enters Goose Creek. Streams to the west and south of this

Figure 1.4



Map Source: USGS (1958)
Ladson, South Carolina Quadrangle
(7.5 Minute Series)

2000 1000 0 2000'
Approximate Scale in Feet

Topographic Map of
Charleston AFB and Vicinity

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

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PARSONS ENGINEERING SCIENCE, INC.

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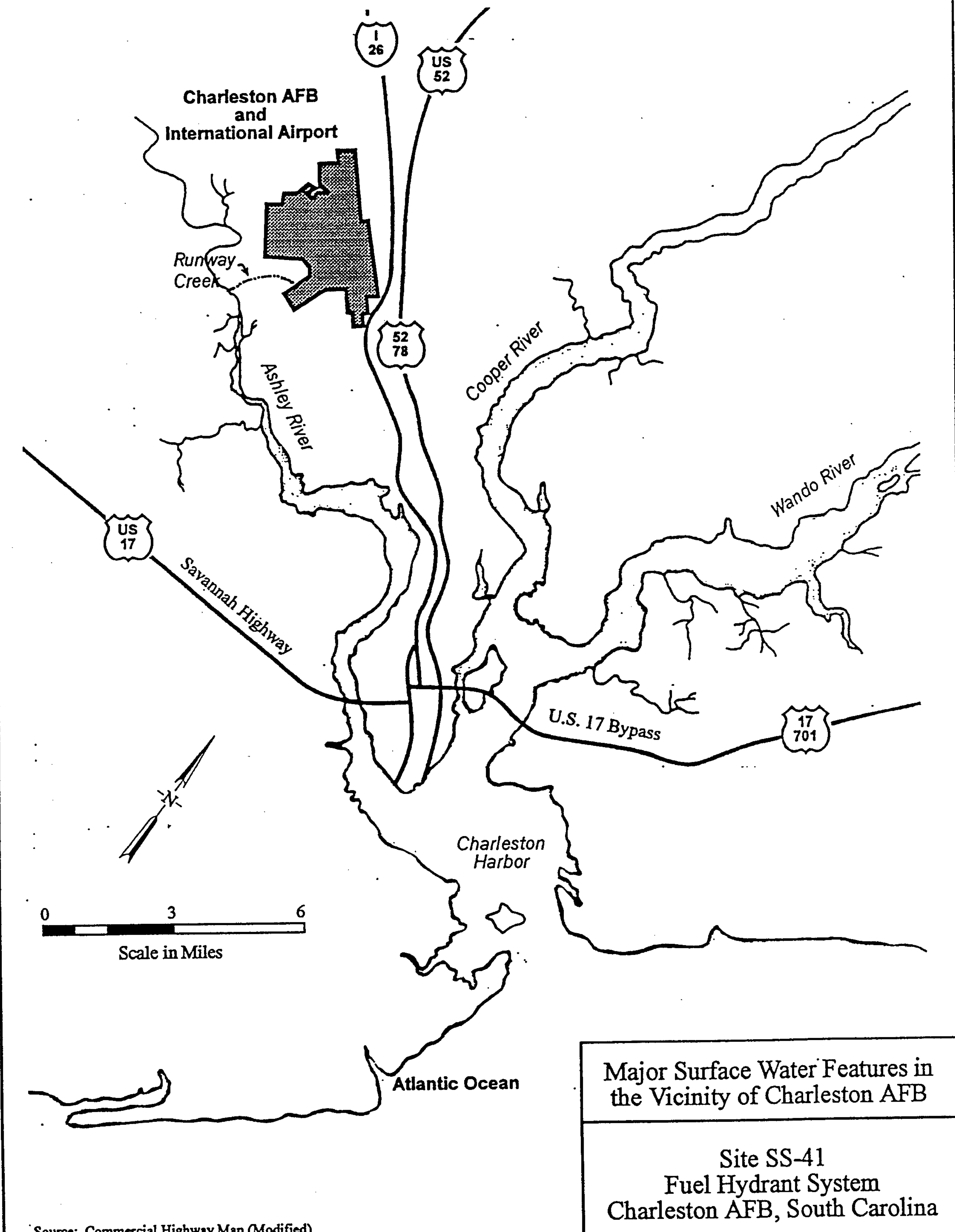


Major Surface Water Features in the Vicinity of Charleston AFB

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

divide ultimately flow towards the west and into the Ashley River.

Wetlands occur in riparian zones along the creeks, streams and ditches as well as in isolated surface depressions connected to adjacent streams via seasonally flooded channels. Wetlands and aquatic habitats that occur within the designated study area are associated with the man-made ditch system draining the flightline, or in seasonally flooded surface depressions in developed areas. Wetland habitats within the designated study area are characterized by low or at most moderate overall value because these habitats are few in number, small in areal extent, and have been disturbed by previous land use practices.

Within the base as a whole, wetlands occur in poorly or somewhat poorly drained nutrient rich soils associated with freshwater creek bottoms, ditches, isolated depressions, and tidal streams. Upland habitats occur in well drained areas underlain by more nutrient poor sandy and loamy soils.

1.5.5 Groundwater

The surficial aquifer occurs within the Ladson Formation, which consists of undifferentiated fine to coarse-grained sand, silty sand, and clay. It is an unconfined (water table) aquifer, which is laterally extensive and is about 20 to 30 feet thick in the vicinity of Charleston AFB. The water table aquifer is recharged by infiltration of precipitation, and discharge from the aquifer occurs primarily as seepage into surface water bodies. Downward migration into the underlying aquifers is limited by the confining Cooper Formation, which yields little or no water and forms a continuous regional aquitard beneath Charleston AFB.

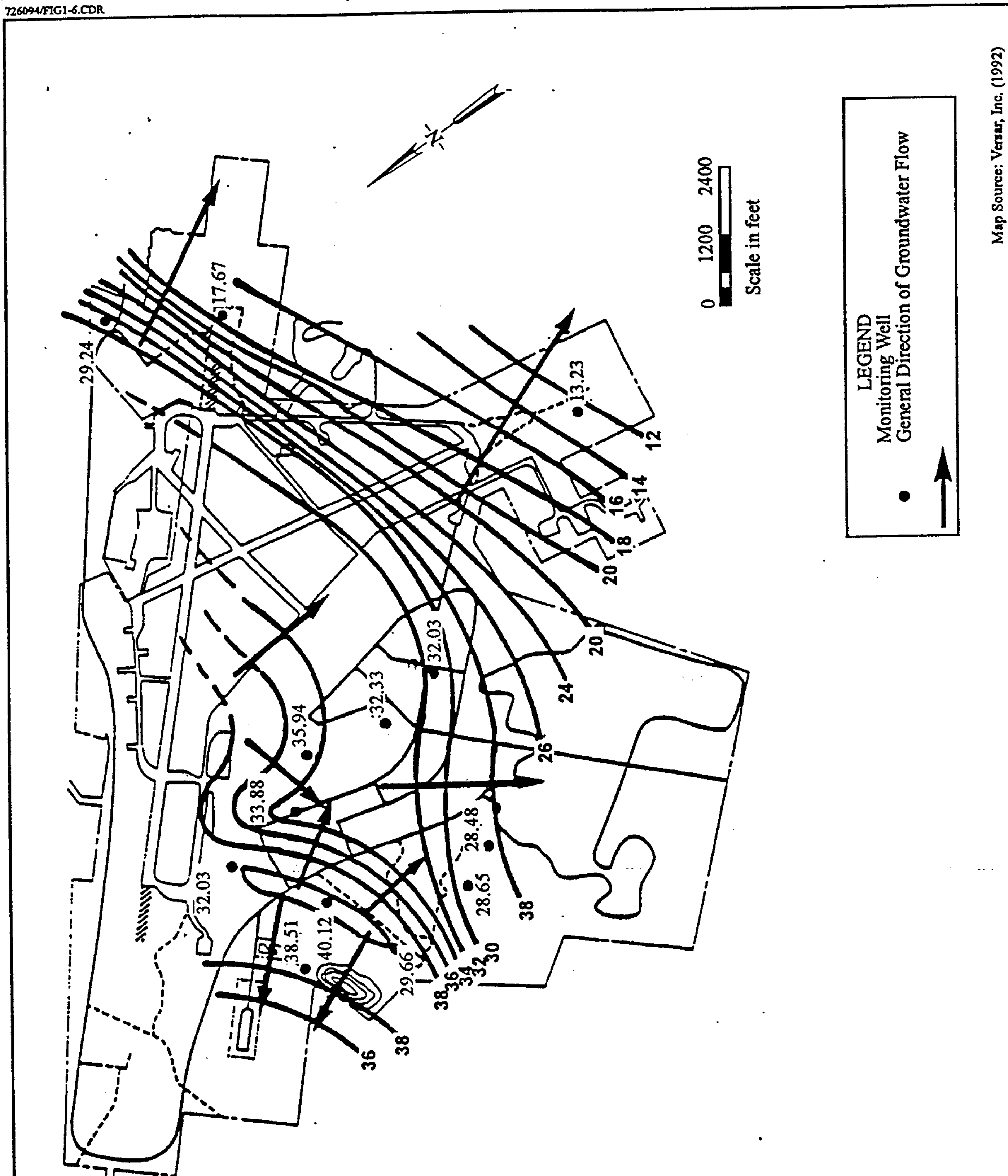
Depth to groundwater in the surficial aquifer ranges from approximately 0.25 to 13 feet below land surface (bls) and the water table surface tends to mimic local topography. Water table fluctuations of between 1 to 6 feet per year are common in the surficial aquifer. The direction of groundwater flow within the surficial aquifer is subject to localized seasonal fluctuations but groundwater generally flows toward the south-southeast or a regional scale in the vicinity of the base (Versar, 1992). Figure 1.6 shows the local groundwater flow directions in the surficial aquifer at Charleston AFB. Groundwater in the surficial aquifer in the vicinity of Site SS-41 flows to the south and exits the base boundary south of runway 3/21. The approximate groundwater travel distance to the base boundary from Building 99 is 4,800 ft, from Building 95 is 6,000 ft, and from former Building 93 is 8,000 ft.

The ambient groundwater quality in the surficial aquifer is good; however, pH is low (<6.0) and iron concentrations are elevated. In much of the state of South Carolina, naturally impaired groundwater exhibits levels of pH, dissolved solids, chloride, iron, manganese, nitrate, and fluoride that exceed drinking water standards. Additionally, sodium concentrations of several hundred milligrams per liter (mg/L) are present in water from aquifers in part of the Lower Coastal Plain (Speiran, et al., 1987).

Groundwater within the vicinity of Charleston AFB is used for industrial and domestic supply purposes. In general, the wells vary in depth from 300 to 500 feet bls and tap the Tertiary aquifer system. Potable drinking water on the base is not obtained from

Figure 1.6

726094/FIG1-6.CDR



Water Table Potentiometric Map
of Charleston AFB

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

groundwater sources because a public water system that utilizes surface water resources provides ample potable water to the area. The only known well of limited public use is located about 3 miles southwest of Charleston AFB. The well is reported to be 380 ft deep and completed open-hole in the Cooper Formation and Santee Limestone. The domestic uses of groundwater are for home heat pump systems and lawn and garden irrigation. Three wells are used to pump groundwater for industrial use in the vicinity of the base (Engineering-Science, 1983). Table 1.1 summarizes the water well data for Charleston AFB and vicinity, and Figure 1.7 shows well locations near the base.

1.5.6 Ecological Setting

This section describes the existing biological resources within the proximity of Site SS-41. (Figure 1.8). The objective of the biological assessment was to characterize upland and wetland vegetation, wildlife, aquatic habitats, rare, threatened and endangered species, and environmentally sensitive areas present within the vicinity of Site SS-41. Information on the actual or potential occurrence of protected species of plants and animals in the study area was obtained via correspondence with the State of South Carolina Natural Heritage Program and the U.S. Fish and Wildlife Service. Other information on biological resources was obtained from the available scientific literature, a previous wetland and protected species assessment conducted at the base by Southeastern Surveying, Inc. and Newkirk Environmental Consultants, Inc. (1991), National Wetland Inventory maps (U.S. Fish and Wildlife Service, 1989), U.S. Geological Survey topographic maps, and aerial photographs.

The field survey of Site SS-41 and associated biological habitats was conducted on September 13-14, 1995. The survey was centered on the area shown in Figure 1.8, which represents "the designated study area", a zone of approximately 0.5 miles around the Fuel Hydrant System. Other information on biological resources was obtained from maps, aerial photographs, and available literature.

1.5.6.1 Upland and Wetland Vegetation

Terrestrial vegetation within the designated study area of Site SS-41 consists of: (1) small isolated pockets of disturbed or maintained (mowed) upland pine forest interspersed with developed areas; and (2) regularly maintained (mowed) and man-made grasslands associated with the flightline area. The pine forest areas are probably remnants of what is defined as the "pine forest community", the most dominant natural upland forest community in the area (U.S. Fish and Wildlife Service, 1980). Prior to man's influence, the dominant upland community type probably consisted of mixed hardwood and fire climax pine forests (U.S. Fish and Wildlife Service, 1980). The pine forest community is dominated by a mix of species, including longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), loblolly pine (*Pinus taeda*) and mixed pine (other species) (U.S. Fish and Wildlife Service, 1980).

All of the isolated forested areas within the designated study area have been significantly impacted by previous and on-going land use practices and in most cases have been maintained by mowing the understory. These habitats are of low to moderate ecological value.

TABLE 1.1
WATER WELL DATA FOR CHARLESTON AFB AND VICINITY
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

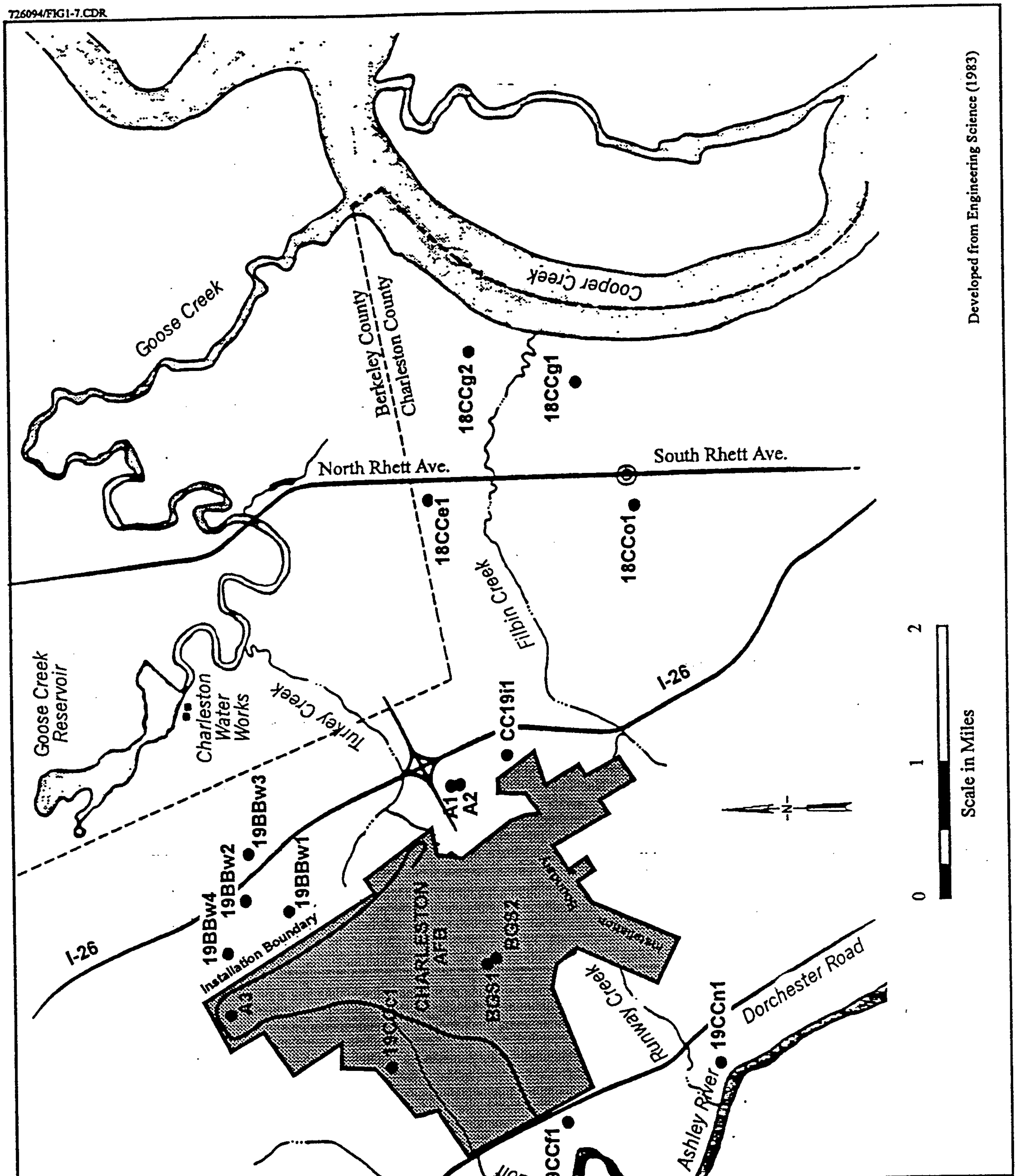
Well ID	Owner/Location	Total Depth (ft)	Screen Length (ft)	Diameter (inches)	Hydrogeologic Unit	Yield (gpm)	Use
A1	Unknown, NE of municipal airport	Unknown	Unknown	Unknown	Unknown	Unknown	Abandoned
A2	Unknown, NE of municipal airport	Unknown	Unknown	Unknown	Unknown	Unknown	Abandoned
A3	CAFB, end of runway 15/33	6	None	48	Qlf	Unknown	Unused
BGS1	CAFB, base gasoline station - Building 210	6	NR	NR	Qlf	NR	Abandoned
BGS2	CAFB, base gasoline station - Building 210	6	NR	NR	Qlf	NR	Abandoned
CC19i1	SCDHEC, Airport Road	17	4	2	Qlf	NR	Monitoring Well
18CCo1	Viola Bunn, North Charleston	325	OH	4	Tef-Tslms	NR	Unused
18CCg1	Raybestos-Manhattan, North Charleston	440	OH	8	Tslms	310	Industrial
18CCg2	Westvaco Corp., North Charleston	450	NR	6	Tslms	NR	Industrial
18CCe1	Westvaco Corp., North Charleston	361	OH	6	Tef-Tslms	40	Public Supply (pool)
19BBw1	James King, Midland Park (NE of base)	300	OH	4	Tef-Tslms	NR	Domestic
19BBw2	Midland Park Elementary School (NE of base)	359	OH	6	Tef-Tslms	40	Unused
19BBw3	Hughes Motor Lines, Midland Park (NE of base)	365	OH	6	Tef-Tslms	115	Industrial
19BBw4	Tom Youmans, Midland Park (NE of base)	321	OH	NR	Tef-Tslms	NR	Domestic
19CCc1	Va. Poly. Inst., Charleston AFB near Bldg. 371	1002	None	2	None	0	Abandoned geothermal test hole
19CCf1	Southern Bell Telephone Co., SW of base	353	OH	6	Tef-Tslms	NR	Abandoned
19CCn1	Mike Crombie, North Charleston	380	OH	4	Tef-Tslms	NR	Domestic

Notes:
gpm = gallons per minute
NR = Not recorded
OH = Open hole

Qlf = Ladson Formation
Tef = Cooper Formation
Tslms = Santee Limestone

Old AAFES gas station was located at Building 210
Source: Engineering-Science, Inc. (1983).

726094/FIG1-7.CDR



Water-Supply and Test Wells near Charleston AFB

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

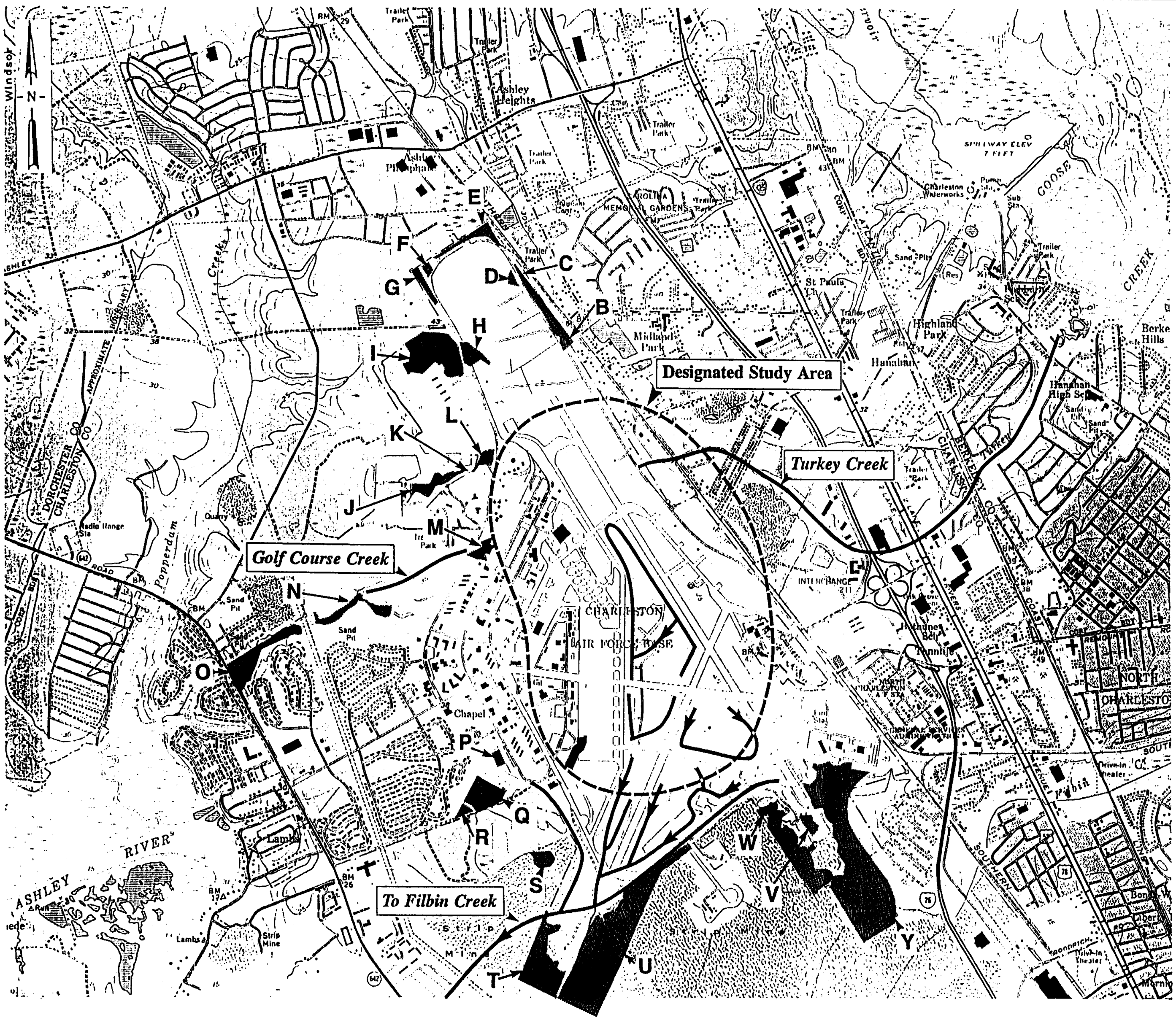


Figure 1.8
Map of Charleston Air Force Base Locations of Designated Study Areas Showing Wetlands, Major Streams and Ditches

Map Source: USGS (1958)
Ladson, South Carolina Quadrangle
(7.5 Minute Series)

2000 1000 0 2000'

Approximate Scale in Feet

Wetland Acreage Chart	
Wetland A	4.304 AC.
Wetland B	1.670 AC.
Wetland C	6.957 AC.
Wetland D	0.921 AC.
Wetland E	4.389 AC.
Wetland F	1.513 AC.
Wetland G	1.181 AC.
Wetland H	4.709 AC.
Wetland I	23.052 AC.
Wetland J	3.709 AC.
Wetland K	0.276 AC.
Wetland L	1.992 AC.
Wetland M	3.148 AC.
Wetland N	7.134 AC.
Wetland O	12.167 AC.
Wetland P	0.194 AC.
Wetland Q	11.651 AC.
Wetland R	0.938 AC.
Wetland S	3.689 AC.
Wetland T	20.907 AC.
Wetland U	67.448 AC.
Wetland V	2.582 AC.
Wetland W	2.621 AC.
Wetland X	7.907 AC.
Wetland Y	93.193 AC.
Total	288.252 ACRES

Legend

Creeks and Ditches

Y Wetlands

Drainage ditches associated with the flightline are approximately 10 to 12 feet in depth and 10 to 15 feet in width. All of the ditches flow to the south, and ultimately connect with Filbin Creek and the Ashley River. The bottoms of the ditches were populated by dense stands of typical wetland plants such as rushes (*Juncus sp.*), woolgrass (*Scirpus cyperinus*), cattail (*Typha latifolia*), black willow (*Salix nigra*), false nettle (*Boehmeria sp.*), boneset (*Bonaria perfoliatum*), and pickerelweed (*Pontedaria sp*). Sides of the ditches were inhabited by small (less than 10 feet tall) trees of sweetgum (*Liquidambar styraciflua*), black willow (*Salix nigra*), red maple (*Acer rubrum*), and oaks (*Quercus sp.*), and woody shrubs such as wax myrtle (*Myrica cerifera*).

Wetland habitats associated with the flightline ditches are of relatively low or at most moderate value because they are relatively disturbed by periodic clearing and mowing, they are small in areal extent, and they are completely isolated from any adjacent terrestrial or wetland habitats (i.e., they provide little edge habitat). The wetland vegetation in the bottom of these ditches do, however, provide some pollutant filtration value and habitat for aquatic animals and birds. The streams at the bottom of the ditches were typically almost completely clogged with dense vegetation, although a few pools and runs were observed during the field survey. Mosquitofish (*Gambusia sp.*) were observed in pools within the streams in all of the ditches examined. Birds and small mammals may also utilize the ditches to some extent for feeding, nesting and resting habitat. The overall ecological value of these ditches as wetland and aquatic habitats, however, is low due to their location adjacent to the flightline, their small extent and their disturbed and isolated nature.

The NWI maps prepared by the U.S. Fish and Wildlife Service (USFWS, 1989) do not indicate the presence of wetlands within the designated study area. Southeastern Surveying, Inc. and Newkirk Consultants, Inc., (1991) conducted a detailed wetland survey of the entire base using the methods specified in the 1987 Corps of Engineers Wetland Delineation Manual (United States Army Engineer Waterways Experiment Station, Environmental Laboratory, 1987). No wetlands reported by Southeastern Surveying, Inc. and Newkirk Consultants, Inc., (1991) occur within the designated study area for Site SS-41 (Figure 1.8)

1.5.6.2 Wildlife Resources

Crows, marsh hawks, various egrets, and killdeer were observed in and adjacent to the ditches at various locations during the field survey, but overall, the ditches provide habitat of low value for wildlife in this area. Noise from jet aircraft and airplane and truck traffic in the flightline area provide a relatively constant level of human disturbance not tolerated by many forms of wildlife. The ditches also appear to have been mowed periodically, they are small in areal extent, and they are not associated with any large continuous mosaics of wetland or upland vegetation (i.e., little edge habitat). The ditches also receive surface runoff from the runway as well as discharge from two outfall pipes (apparently storm sewer discharge from adjacent apron areas). Water in the stream within the ditches during the field survey was turbid, apparently due to silt from runoff and/or outfall discharges. All of these factors combine to provide low value wildlife habitat.

Upland forested areas within the designated study area also provide low to moderate value habitat for wildlife. The understories in the majority of these areas have been mowed, and the individual stands of forest are small and isolated. Forested habitats are all located in urbanized areas. area for Site SS-41 (Figure 1.8).

1.5.6.3 Aquatic Habitats

Aquatic habitats are present within the ditches and streams in the flightline area and other portions of the designated study area. These connect to higher value systems outside of the designated study area. The following three aquatic areas were identified (please refer to Figure 1.8 for locations of each resource):

- Runway Creek: The numerous small creeks and ditches in the runway system all drain Site SS-41. These creeks and ditches eventually combine and discharge to Runway Creek on the south end of the base. Runway Creek ultimately discharges to Filbin Creek, and from there into the Ashley River, a high quality coastal estuarine resource. Filbin Creek enters the Ashley River over 1.5 miles south of the designated study area.
- Golf Course Creek: Several small tributaries and ditches combine and discharge into Golf Course Creek, which in turn flows west into Popperdam Creek, a tributary of the Ashley River, a high quality coastal resource. Golf Course Creek itself is a very low value aquatic habitat since it consists of a concrete lined channel in the majority of the upper portion. Popperdam Creek appears to be a relatively high value aquatic habitat. The confluence of Golf Course Creek and Popperdam Creek is located approximately 1.5 miles to the west of the edge of the designated study area (Figure 1.8).
- Unnamed tributary of Turkey Creek: This tributary is located near runway 15/33 and discharges to the east into Goose Creek, a high quality coastal resource and the other main watershed located in the study area. The confluence of Turkey Creek and Goose Creek is located approximately 2 stream miles to the east of the edge of the designated study area (Figure 1.8).

1.5.6.4 Environmentally Sensitive Areas

Environmentally sensitive areas would include areas such as high quality wetlands, high value aquatic habitats (fish spawning areas or valuable feeding areas), or mature stands of undisturbed upland forest. These types of resources do not exist within the designated study area.

1.5.6.5 Endangered, Threatened and Special Concern Species

Table 1.2 summarizes information on state- and Federally-listed species which are known to occur in Charleston County. Table 1.2 was composed from information provided by the U.S. Fish and Wildlife Service and the State of South Carolina Department of Natural Resources. Table 1.2 also includes species listed by the State of South Carolina as being threatened, endangered or concern. Although many species are listed for the County, the designated study area for Site SS-41 does not provide suitable

Table 1.2. List of State and federally Listed Species Recorded In Charleston County, South Carolina, and Preferred Habitats. Sources: U.S. Fish and Wildlife Service (1995) and S.C. Heritage Trust Program Database (1995)

Scientific Name	Common Name	Fed Status[1]	State Status[2]	Preferred Habitat
ANIMALS				
Accipiter cooperii	Cooper's hawk		SC	Deciduous forests and stands of conifers next to fields
Acipenser brevirostrum	Shortnose sturgeon	FE		Marine fish known to spawn in freshwater portions of major coastal rivers
Acris crepitans crepitans	Northern cricket frog		SC	Swamps and bottomland hardwoods
Ambystoma cingulatum	Flatwoods salamander		SE	Mesic pine/wiregrass flatwoods dominated by longleaf or slash pine; breed in, shallow, acidic, ephemeral ponds in wet prairie/savannahs
Ambystoma tigrinum tigrinum	Eastern tiger salamander		SC	Very mesic forest; mesic to xeric forest
Caretta caretta	Loggerhead turtle	FT		Coastal marine and inshore waters; nests on sandy beaches
Charadrius melodus	Piping plover	FT		Bare, dry sandy habitat in inland and coastal areas
Charadrius wilsonia	Wilson's plover		ST	Beaches, dunes, mudflats
Chelonia mydas	Green sea turtle	FT		Coastal and inshore waters; nests on sandy beaches
Clemmys guttata	Spotted turtle		SC	Hydric and lower floodplain; very mesic forests
Condylura cristata	Star-nosed mole		SC	Fields and meadows; damp or muddy soil near water
Corynorhinus rafinesquii	Rafinesque's big-eared bat		SE	Caves, mine tunnels, buildings
Dendroica virens	Black-throated green warbler		SC	Forests

[1]**Federal Status:**
FE=Federal Endangered
FT=Federal Threatened

[2]**State Status:**
SE=State Endangered
ST=State Threatened
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Table 1.2. List of State and federally Listed Species Recorded In Charleston County, South Carolina, and Preferred Habitats. Sources: U.S. Fish and Wildlife Service (1995) and S.C. Heritage Trust Program Database (1995)

Scientific Name	Common Name	Fed Status[1]	State Status[2]	Preferred Habitat
Dermochelys coriacea	Leatherback sea turtle	FE		Coastal and inshore waters; nests on sandy beaches
Elanoides forficatus	American swallow-tailed kite		SE	Forest, fields, pastures
Falco peregrinus	Peregrine falcon	FE		Open areas along rivers, near lakes in coastal region; nests in steep cliffs or old eagle nests
Haliaeetus leucocephalus	Bald eagle	FT		Large undisturbed rivers, lakes and marshes
Ictinia mississippiensis	Mississippi kite		SC	Fields, pastures
Lasiurus cinereus	Hoary bat		SC	Forests
Lepidochelys kempii	Kemp's ridley sea turtle	FE		Coastal and inshore waters; nests on sandy beaches
Limnothlypis swainsonii	Swainson's warbler		SC	Freshwater marshes, ponds
Melanerpes erythrocephalus	Red-headed woodpecker		SC	Forests
Microtus pennsylvanicus	Meadow vole		SC	Fields and meadows
Micrurus fluvius	Eastern coral snake		SC	Moist, dense hammocks near ponds or streams in hardwood forests, pine flatwoods, rocky hillsides and canyons
Mycteria americana	Wood stork	FE		Feeds in shallow ponds, tidal pools and marshes; nests in cypress, hardwoods and mangrove swamps.
Myotis austroriparius	Southeastern myotis		ST	Caves, mine tunnels, hollow trees, buildings, culverts, bridges
Neotoma floridana	Eastern woodrat		SC	Hummocks, swamps and cabbage palmetto

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Scientific Name	Common Name	Fed Status[1]	State Status[2]	Preferred Habitat
Pelecanus occidentalis	Brown pelican		SC	Coastal marine and estuarine waters
Phoca vitulina	Harbor seal		SC	Mouths of rivers and harbors
Picoides borealis	Red-cockaded woodpecker	FE		Forages in mature undisturbed pine forests at least 30 years old and open understory; nests in mature pine forests with > 70 year old fungus infected heartwood;
Plegadis falcinellus	Glossy ibis		ST	Fresh or salt water marshes
Pseudobranchus striatus	Dwarf siren		ST	Shallow ditches, cypress swamps, weed choked ponds (particularly water hyacinth)
Rana capito	Gopher frog		SC	Gopher tortoise or crawfish burrows
Sciurus niger	Eastern fox squirrel		SC	Pine forests with interspersed clearings
Seminatrix pygaea	Black swamp snake		SC	Swamps, cedar and cypress ponds, canals, drainage ditches (particularly ones choked by water hyacinths)
Sterna antillarum	Least tern		ST	Estuarine and coastal waters
Trichechus manatus	West Indian manatee	FE		Coastal waters, inland waterways, rivers and estuaries
Tyto alba	Barn-owl		SC	Farmyards, marshes and fields
Ursus americanus	Black bear		SC	Forests and swamps
Vermivora bachmanii	Bachman's warbler	FE		Canebrakes and thickets in and adjacent to mature hardwood swamps
PLANTS				
Amaranthus pumilus	Seabeach amaranth	FT		Beach dunes

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Scientific Name	Common Name	Fed Status[1]	State Status[2]	Preferred Habitat
Anthaenantia rufa	Purple silkyscale		SC	Low woodlands, sandhills
Botrychium lunarioides	Winter grape-fern		SC	Old fields and pastures
Calopogon barbatus	Bearded grass-pink		SC	Open savannahs, low meadows, pinelands
Canna flaccida	Bandana-of-the-everglades		SC	Pine savannahs and marshes
Carex decomposita	Cypress-knee sedge		SC	Marshes and swamp forests
Chasmanthium nitidum	Shiny spikegrass		SC	Sloughs
Coreopsis gladiata	Southeastern tickseed		SC	Marshes, bogs, wet pine barrens
Cyperus tetragonus	Piedmont flatsedge		SC	Sandy depressions and brackish marshes
Dyschoriste humistrata	Swamp dyschoriste		SC	Low woodlands
Eleocharis vivipara	Viviparous spike-rush		SC	Marshy areas, aquatic areas
Eupatorium fistulosum	Hollow joe-pye weed		SC	Upland and alluvial woodlands
Habenaria quinqueseta	Long-horn orchid		SC	Low pinelands and pine or oak flatwoods
Helenium pinnatifidum	Southeastern sneezeweed		SC	Pocosins, bays, bogs and savannahs
Ipomoea macrorhiza	Large-stem morning-glory		SC	Sandy clearings and beaches
Ipomoea stolonifera	Beach morning-glory		SC	Beach dunes
Lepuropetalon spathulatum	Southern lepuropetalon		SC	Sandy ditches
Lindera melissifolia	Pondberry	FE		Seasonally flooded shallow depressions and wetlands; lime sinks with pond cypress and blackgum surrounded by mixed oak-pine forest
Listera australis	Southern twayblade		SC	Rich humus of low moist woods, pine barrens and thickets

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Scientific Name	Common Name	Fed Status[1]	State Status[2]	Preferred Habitat
Lygodium palmatum	Climbing fern		SC	Wet thickets in sandy or acid soil
Orobanche uniflora	One-flowered broomrape		SC	Mature undisturbed woods
Oxypolis canbyi	Canby's dropwort	FE		Carolina Bays, shallow flatwoods, pond margins, wet pine savannahs, cypress-pine swamps and sloughs
Peltandara sagittifolia	Spoon-flower		SC	Marshy areas
Pieris phillyreifolia	Climbing fetter-bush		SC	Swamps
Platanthera integra	Yellow fringeless orchid		SC	Swamps, pine barrens, flatwoods
Psilotum nudum	Whisk fern		SC	Upland and alluvial woodlands
Rhynchospora inundata	Drowned hornedrush		SC	Ditches and marshes
Sageretia minutiflora	Tiny-leaved buckthorn		SC	Sand and shell dunes and hammocks
Sarracenia rubra	Sweet pitcher plant		SC	Savannahs and marshy areas
Schwalbea americana	Chaffseed	FE		Fire-maintained wet savannahs and pine woodlands
Scleria baldwinii	Baldwin nutrush		SC	Low pinelands
Spiranthes laciniata	Lace-lip ladies'-tresses		SC	Cypress swamps, marshes and pools
Syngonanthus flavidulus	Yellow pipewort		SC	Bogs, savannahs and low pinelands
Thalia dealbata	Powdery thalia		SC	Wet ditches and margins of swamp forests
Triphora trianthophora	Nodding pogonia		SC	Damp mature woods and thickets

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habitat for any state- or Federally-listed species of plants or animals, nor were any of these species observed during the field survey.

Southeastern Surveying, Inc. and Newkirk Consultants, Inc., (1991) conducted a previous survey of state- and Federally-listed species for the entire Charleston Air Force Base. No species were found on any portions of the base at the time of that survey. The base had provided foraging habitat for the red cockaded woodpecker prior to hurricane Hugo, but the storm destroyed the majority if not all of this habitat.

2. SITE CHARACTERIZATION

Additional site characterization was conducted to define the nature and extent of soil and groundwater contamination at Fuel Hydrant System Site SS-41. Site characterization activities included direct-push sampling of groundwater and lithologic characterization using cone penetrometry (CPT); performance of soil borings; installation of monitoring wells; and collection of soil, groundwater, surface water, and sediment samples for analysis of contaminant concentrations. In general, procedures described in the Sampling and Analysis Plan (SAP) were adhered to during the site characterization activities. Deviations from the SAP procedures are noted in the descriptions of site characterization activities in the following sections.

2.1 GROUNDWATER SCREENING SURVEY

Prior to installing additional monitoring wells, groundwater screening was conducted using direct-push (hydraulic-driven) sampling devices to provide a rapid assessment over the large study area of the fuel hydrant system. Groundwater samples were collected using CPT at 32 locations at Site SS-41 shown on Figure 2.1. At two of the CPT sampling locations, groundwater samples were collected at two depths to evaluate the vertical extent of contamination. A field gas chromatograph (GC) instrument was used to analyze groundwater samples for on-site screening to identify areas of potential contamination. Three one-inch-diameter piezometers (PZD1S, PZD1D, and PZD2) were also installed using CPT equipment to map the potentiometric heads within the surficial aquifer on the west side of the flightline ditch.

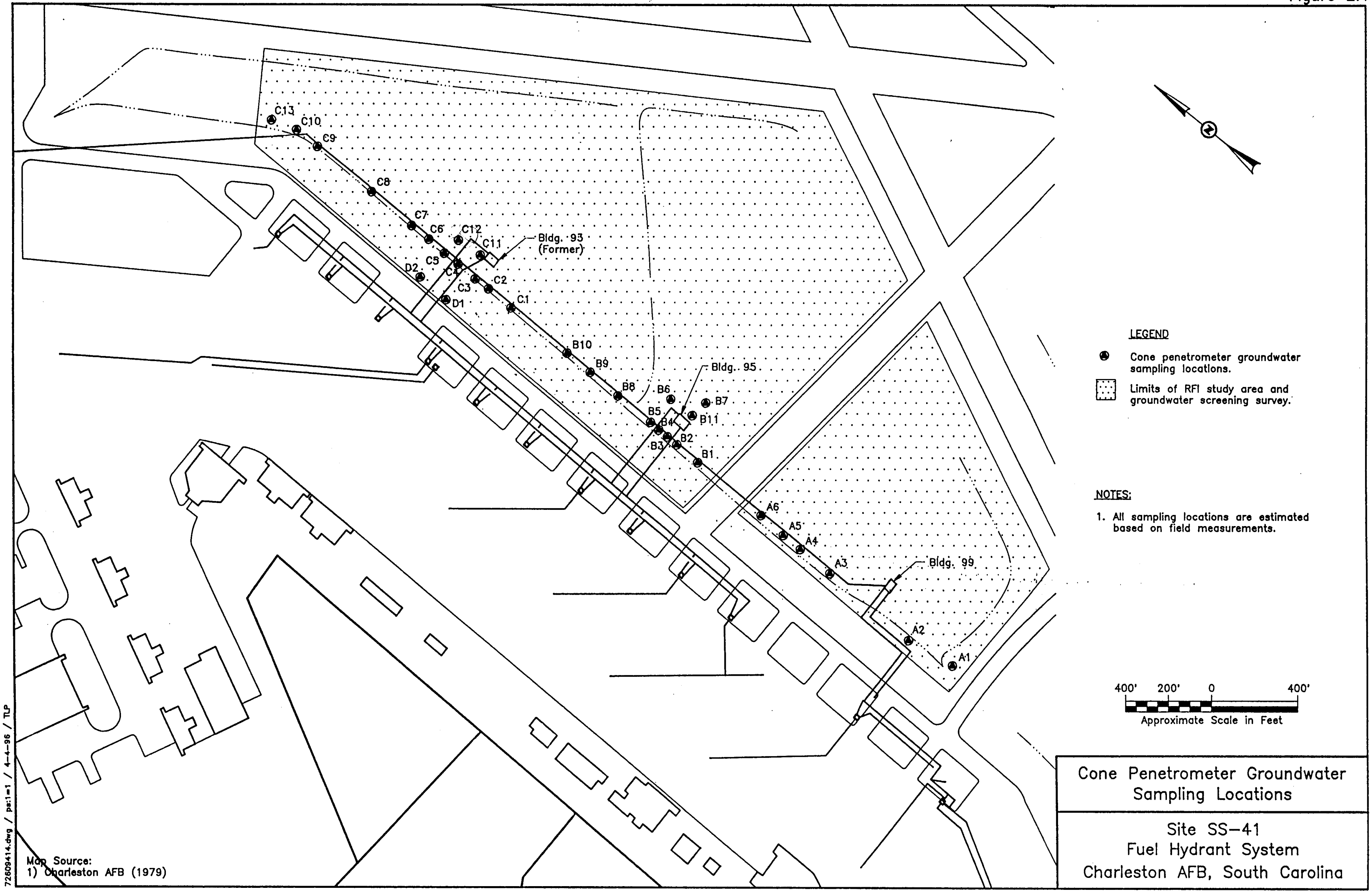
Direct-push screening was performed using CPT probes equipped with the In-Situ Group's Hydrocone® and Piezocone® tools. Sampling data collected from the CPT survey was used to map areas of groundwater contamination, and to characterize site lithology. Cone penetrometry was performed in accordance with ASTM D-3341 to provide estimates of soil characteristics and aquifer conditions.

The Hydrocone® groundwater sampler was used to collect groundwater samples, and to estimate hydraulic conductivity of different sampling depths based on the rate of groundwater recharge into the sampling chamber. The Hydrocone® sampling tool is hydraulically pushed to the desired sampling depth and a sampling sleeve is retracted to expose a small diameter screen. Hydrostatic pressure forces groundwater into the screen and sampling chamber and the sample is then retrieved to the surface by withdrawing the probe from the ground.

Aqueous samples collected during groundwater screening were analyzed for benzene, toluene, ethylbenzene, and total xylenes using the field GC. The BTEX target compounds were analyzed since they are expected to be the most prevalent, water-soluble components of concern in JP-4 jet fuel. A modified field QA/QC program was used for the field GC sampling program.

The boundaries of the groundwater screening survey, and the study in general, along with the sampling locations are shown in Figure 2.1. Direct-push sampling points were placed along the entire length of the 8-inch primary fuel pipeline which parallels the

Figure 2.1



PARSONS ENGINEERING SCIENCE, INC.

flightline ditch inside the study area. Direct push groundwater sampling points were generally located between the primary fuel pipeline and the flightline ditch More concentrated groundwater sampling was conducted around the fuel pumping stations, USTs, valve pits, and drain points. A total of 34 groundwater samples were collected using the CPT. As shown in Figure 2.1, the CPT groundwater survey was divided into four quadrants (A, B, C, D).

Vertical Hydrocone® sampling intervals were based on field GC analytical results, Piezocone® observations and field judgment. Sampling depths and analytical results from the field GC are summarized in Table 2.1. Field GC analytical results indicate that the only sample containing BTEX constituents exceeding any of the risk based screening levels (RBSLs) under the RBCA was C12-10 with a benzene concentration of 82 micrograms per liter (µg/L).

2.2 MONITORING WELL INSTALLATION AND SOIL BORINGS

2.2.1 Groundwater Monitoring Wells and Piezometers

Locations for new monitoring wells and piezometers, shown in Figure 2.2, were based on results from the CPT investigation and on the locations of the fuel pumping stations, USTs, valve pits, and drain points. A total of eight new wells and three piezometers were installed near Building 95 fuel pumping station and former Building 93 fuel pumping station. The wells were installed to monitor shallow groundwater conditions. Prior to drilling, Charleston AFB personnel cleared all drilling locations for underground utilities.

No additional wells were installed near Building 99 fuel pumping station. The six wells previously installed around Building 99 appear to adequately delineate the fuel contamination in this area, based on existing data. Well construction records for these six wells are provided in Appendix A for reference.

The new wells (MW-7 through MW-14) were constructed to monitor shallow surficial aquifer conditions according to procedures described in the RFI/CMS Fuel Hydrant System Work Plan and SAP. Each of the monitoring wells was constructed of nominal 2-inch-diameter PVC 0.01-inch slot screen and casing. The borehole for each well was advanced using a hollow stem auger drilling rig equipped with 8-inch O.D. augers. The wells were constructed to depths ranging from 14 to 17 feet below land surface (bls) with 10-foot screen sections. The well screens were positioned so that approximately 2 or 3 feet of screen extends above the water table where possible. To avoid problems with running sands, the wells were constructed inside the augers. Both monitoring well filter sand and bentonite were carefully poured into the auger sections surrounding the well materials as the augers were slowly withdrawn. Well construction records are provided in Appendix A. Well screen intervals and well top-of-casing elevations are summarized in Table 2.2.

2.2.2 Soil Borings and Soil Sampling

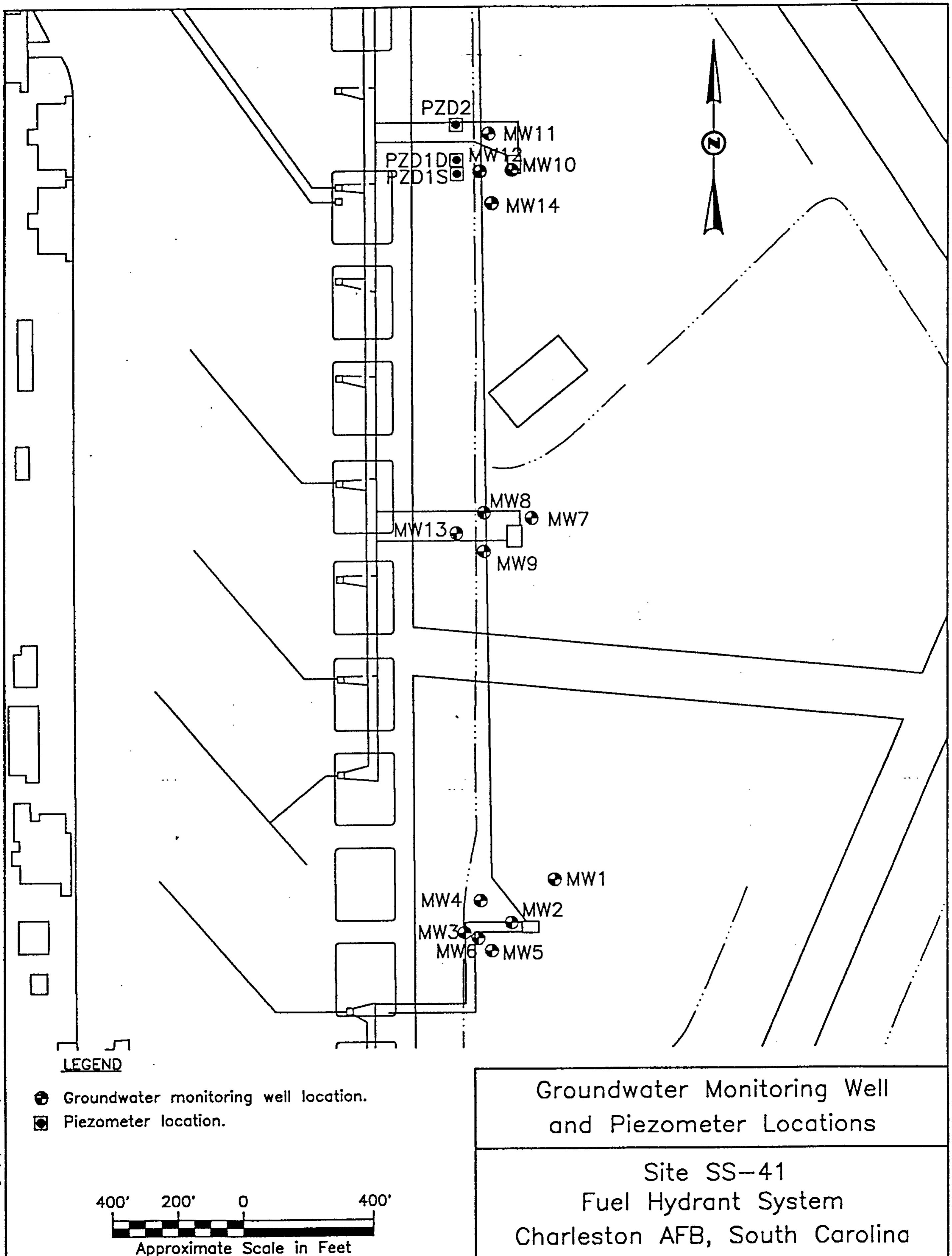
A total of eleven soil borings were advanced along the fuel hydrant system during the investigation to assess soil quality and to delineate potential soil contamination. Figure 2.3

TABLE 2.1
CONE PENETROMETER GROUNDWATER SAMPLE RESULTS BY FIELD GC FUEL HYDRANT SYSTEM (SITE SS-41) CHARLESTON AFB, SOUTH CAROLINA

Sample No.	Depth (ft.bls)	Benzene	Toluene	Ethyl Benzene	Total Xylenes	Total BTEX
A1-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
A2-14	14	<1.0	<1.0	<1.5	<1.5	<1.5
A3-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
A4-12	12	<1.0	<1.0	<1.5	<1.5	<1.5
A5-11	11	<1.0	<1.0	<1.5	<1.5	<1.5
A6-16	16	<1.0	<1.0	<1.5	<1.5	<1.5
B1-12	12	<1.0	<1.0	<1.5	<1.5	<1.5
B2-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
B3-13	13	<2.0	<10	<1.5	1.1	1.1
B3-13	21	<2.0	<10	1.6	6.9	8.5
B4-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
B5-16	16	<1.0	<1.0	<1.5	<1.5	<1.5
B6-14	14	<1.0	<1.0	<1.5	<1.5	<1.5
B7-12	12	<1.0	<1.0	<1.5	<1.5	<1.5
B8-15	15	<1.0	<1.0	<1.5	<1.5	<1.5
B9-13	13	<1.0	<1.0	<1.0	<1.0	<1.5
B9-13 (dup.)	13	<1.0	<1.0	<1.0	<1.0	<1.5
B10-13	13	<1.0	1.1	<1.0	<1.0	<1.5
B11-13	13	<1.0	<1.0	<1.0	<1.0	<1.5
B11-13 (dup.)	13	<1.0	<1.0	<1.0	<1.0	<1.5
C1-13	13	<1.0	<1.0	<1.0	<1.0	<1.5
C2-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
C3-13	13	<1.0	<2.0	<1.5	<1.5	<2.0
C3-29	29	<1.0	<1.0	<1.5	<1.5	<1.5
C4-13	13	<1.0	5.1	<1.5	<1.5	5.1
C5-13	13	0.6 J	<1.0	<1.5	<1.5	<1.5
C6-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
C7-13	13	<1.0	<1.0	<1.5	<1.5	<1.5
C7-13 (dup.)	13	<1.0	<1.0	<1.5	<1.5	<1.5
C8-13	13	<1.0	<1.0	<1.0	<1.0	<1.5
C9-10	10	<1.0	<1.0	<1.0	<1.0	<1.5
C10-10	10	<1.0	<1.0	<1.0	<1.0	<1.5
C10-10 (dup.)	10	<1.0	<1.0	<1.0	<1.0	<1.5
C11-13	13	<5.0	<10	1.9	9.6	11.5
C12-10	10	82	<1.0	13J	400	482
C13-10	10	<1.0	<1.0	<1.0	<1.0	<1.5
D1-10	10	<1.0	<1.0	<1.0	<1.0	<1.5
D2-10	10	<1.0	<1.0	<1.0	<1.0	<1.5

Notes: Samples analyzed by field GC August 21 - 24, 1995.
Results in µg/L.

Figure 2.2



Groundwater Monitoring Well and Piezometer Locations

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

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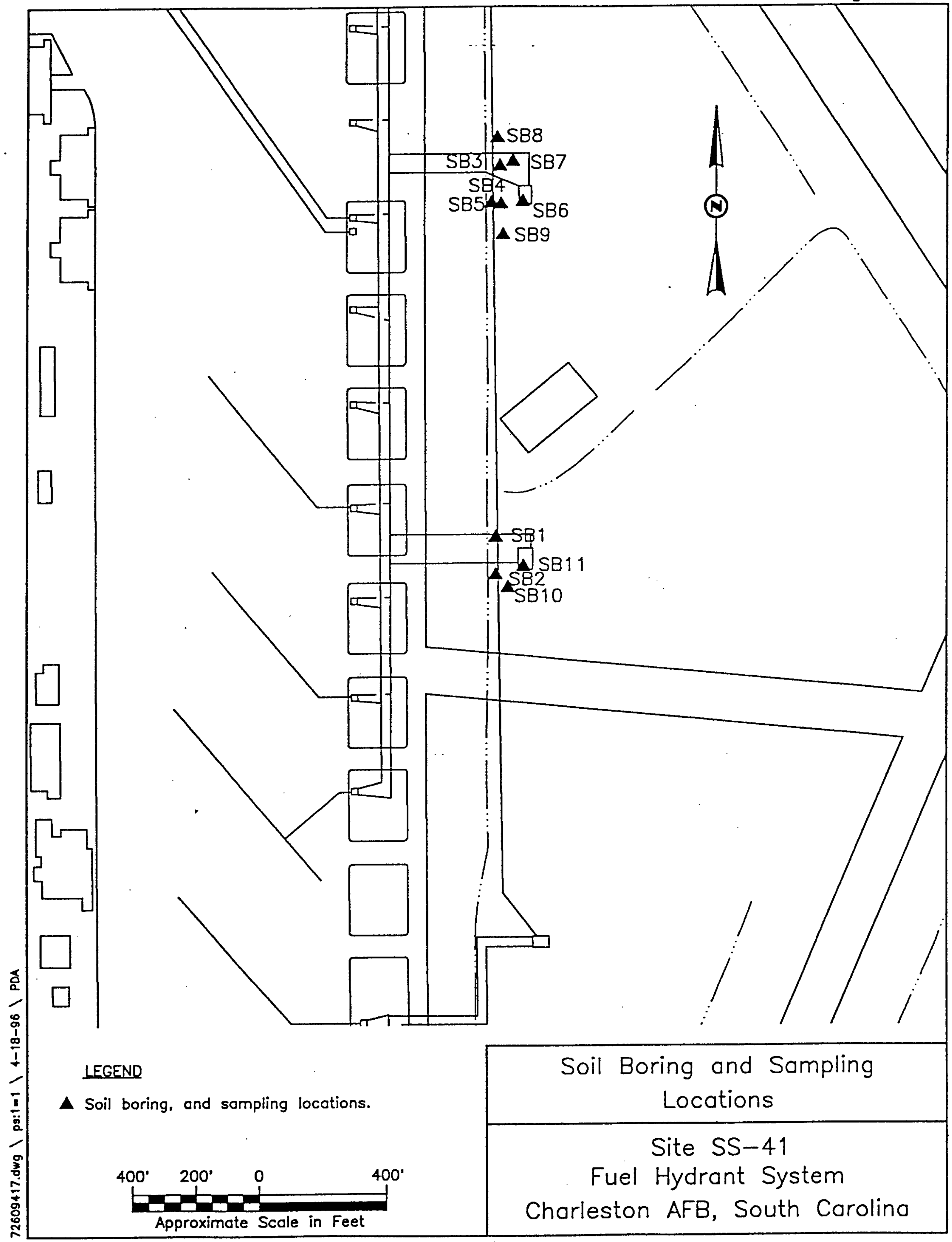
TABLE 2.2
GROUNDWATER MONITORING WELL CONSTRUCTION DATA
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

Well No.	Screened Interval (ft. bls)	Top of Casing Elevation (ft. msl)	Depth to Groundwater 16-Oct-95	Water Table Elevation 16-Oct-95	Depth to Groundwater 13-Nov-95	Water Table Elevation 13-Nov-95
MW-1	6.14-11.14	38.55	7.39	31.16	8.02	30.53
MW-2	7.0-12.0	38.19	9.30	28.89	9.35	28.84
MW-3	3.0-13.0	35.22	9.85	25.37	10.11	25.11
MW-4	7.15-12.15	36.40	10.75	25.65	11.00	25.40
MW-5	3.0-13.0	35.41	9.03	26.38	9.39	26.02
MW-6	23.0-28.0	35.12	9.74	25.38	9.87	25.25
MW-7	7.43-16.25	41.24	9.91	31.33	10.38	30.86
MW-8	4.35-13.27	39.77	12.30	27.47	12.48	27.29
MW-9	6.35-16.27	40.14	12.25	27.89	12.47	27.67
MW-10	6.35-15.27	39.90	11.04	28.86	14.22	25.68
MW-11	4.35-13.77	37.56	9.55	28.01	10.75	26.81
MW-12	4.35-13.77	38.57	11.02	27.55	11.04	27.53
MW-13	4.35-13.77	36.80	9.66	27.14	9.78	27.02
MW-14	4.35-13.77	40.96	13.20	27.76	13.33	27.63
PZD-1S	10-15	36.13	NM	NM	8.69	27.44
PZD-1D	30-35	36.13	NM	NM	8.59	27.54
PZD-2	10-15	36.18	NM	NM	5.61	30.57

Notes: All measurements in feet.
Depth to water measured from top of casing.
Elevations relative to feet mean sea level (msl).
NM = Not measured.
bls = Below land surface.

Figure 2.3



Soil Boring and Sampling Locations

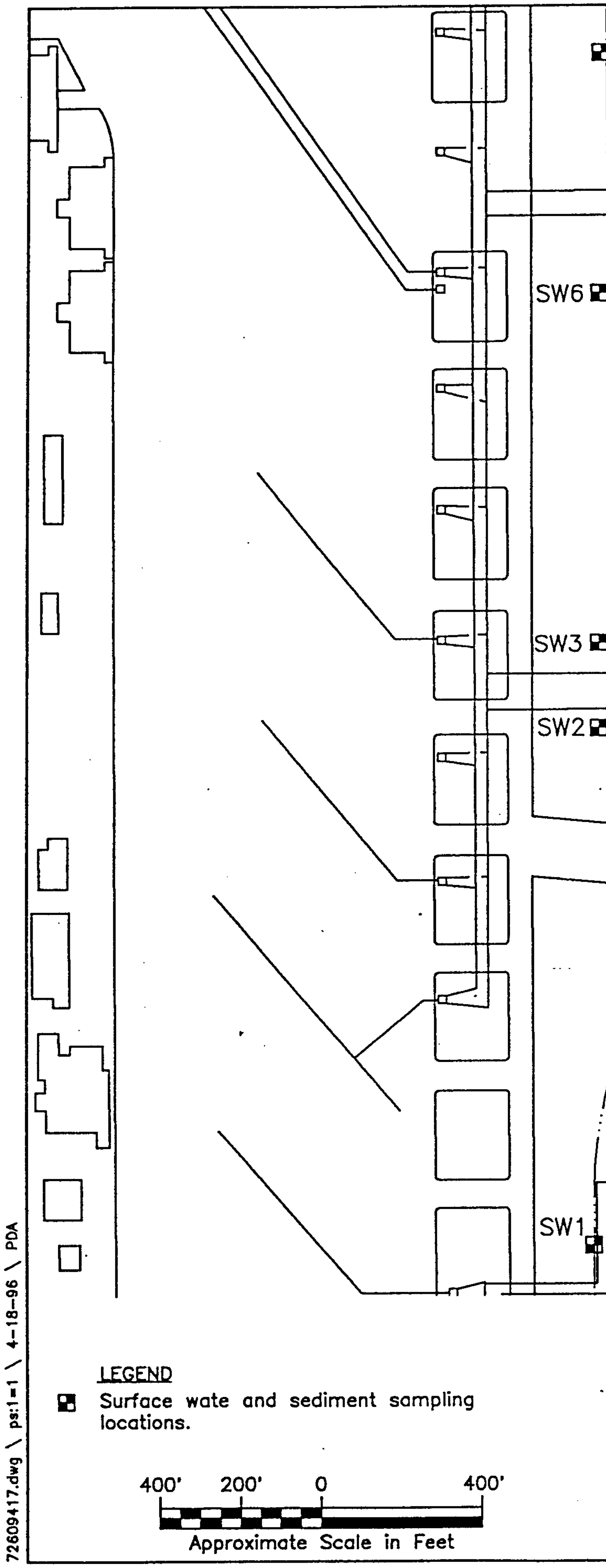
Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

shows the locations of the soil borings performed at Site SS-41. As with the monitoring well installations, the additional soil boring locations were based largely on the direct-push field screening results and identification of potential hydrocarbon source areas. Four of the soil borings (SB-1, SB-2, SB-10 and SB-11) were located at Building 95 fuel pumping station. An additional seven soil borings (SB-3, SB-4, SB-5, SB-6, SB-7, SB-8, and SB-9) were advanced in and around former Building 93 fuel pumping station. All soil borings were advanced to the water table and sampled continuously with split spoon samplers as described in the SAP. A portion of each sample was screened with a PID for volatile organic vapors, and the sample with the highest PID reading from each borehole was submitted for laboratory analyses of VOCs, SVOCs, metals, TPH, phosphorous, nitrogen, and pH. Monitoring wells were installed in boreholes SB-1, SB-2, SB-3, and SB-4. Boreholes which were not used for monitoring wells were abandoned with cement grout per state regulations. Drill cuttings were placed in labeled 55-gallon steel barrels.

The soil samples were collected with a 2.5-foot long California Modified split-tube sampler with a 3-inch inside diameter. The lower 2 feet of the sampler contained the split-tube barrel, while the upper 6 inches contained a solid barrel to collect "slough" soil that was not kept for sampling purposes. Each split-tube barrel was lined with eight 3-inch long, 3-inch diameter stainless steel sections that had previously been decontaminated as described in the SAP. From each 2-foot split-tube section, the upper 1-foot and the lower 1-foot interval were each considered to be a single sample. The sampler was driven 2.5 feet into the ground, beginning at ground surface, using a truck-mounted drill rig. Upon collecting a sample, each 3-inch stainless steel section was covered with 3-inch diameter Teflon® tape and sealed with air tight plastic caps. An indelible ink marker was used to label each 3-inch sample section.

Following the collection of a soil sample, the borehole was advanced 2.5 feet using hollow-stem augers on a truck-mounted drill rig. The next sample was then collected from the bottom of the boring while the augers remained in the boring to prevent collapse of the borehole. In some instances the boring remained open allowing the sampler to be advanced without continuously using the augers, thus minimizing drill cuttings generated. The sampling process continued at 2.5-foot intervals or as directed by the field geologist. If insufficient recovery occurred with any split-tube sample, another sample tube was advanced immediately below the preceding sample depth to collect the required soil volume. Lithologic classification was conducted for every split-tube sample.

After all samples had been obtained from a boring, samples for chemical analyses were selected from the 1-foot section having the highest corresponding VOC soil vapor concentrations, as measured in the uppermost 3-inch interval of those 1-foot sections. The field VOC screening portion of soil was immediately transferred to a 250-ml glass jar for headspace analyses. The jar was sealed with aluminum foil and allowed to stand for approximately 10 minutes. The foil was then pierced with the tip of the PID and a total organic vapor reading was recorded on the boring log. If no VOC vapors were detected in any sections of a boring, the deepest section in that boring, collected above the estimated seasonal high water table, was selected for laboratory analysis. The soil sampling program included collection of field QA duplicate, rinseate blank, and field blank samples according to the SAP.



Surface Water and Sediment Sampling Locations

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

Surface water samples were collected first at each location, followed by collection of sediment samples. Sediment and surface water sampling was performed according to the sampling protocols presented in the SAP. Samples were analyzed in the laboratory for VOCs, SVOCs, metals, and TPH as summarized in the SAP. Field analyses were performed on surface water samples for DO, temperature, pH, and conductivity. In addition, surface water samples were analyzed in the field for ferrous (dissolved) iron, nitrate and sulfate using the HACH colorimetric test instruments. Field QA samples included duplicates, ambient blank, and rinseate blank.

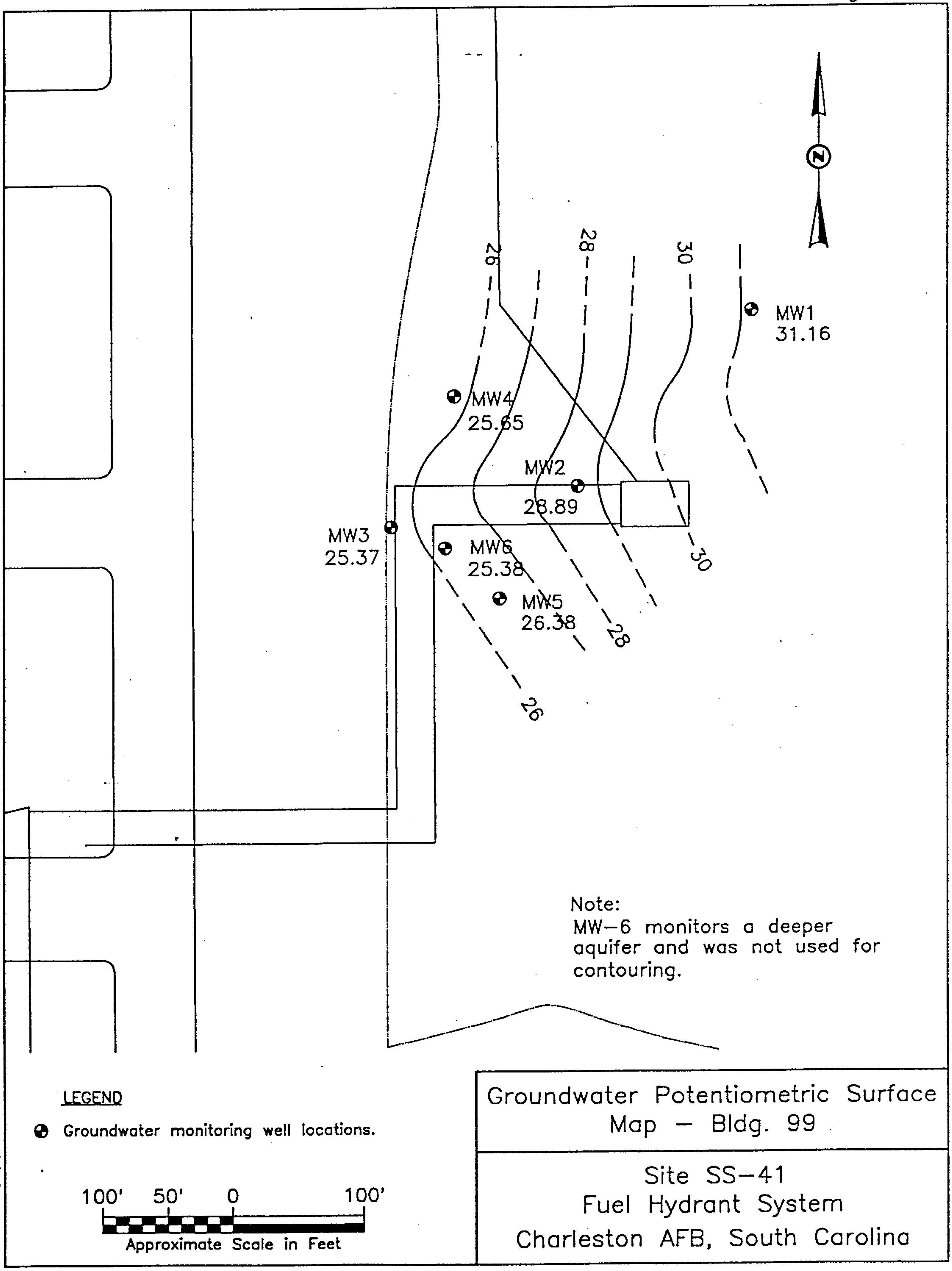
2.5 SITE HYDROGEOLOGIC FRAMEWORK

Groundwater elevation data were collected on October 16, and November 11, 1995 (see Table 2.2). Groundwater potentiometric surface maps were prepared using the data from October 16, 1995. The water table potentiometric surface maps for the three individual fuel pumping station sites at Site SS-41 (Buildings 99, 95, and 93) are shown in Figures 2.5, 2.6, and 2.7 , respectively. Based on the October 16, 1995 data, shallow groundwater at all three of the fuel pumping station sites (on the east side of the flightline drainage ditch) moves from northeast to southwest toward the flightline drainage ditch. On the west side of the flightline drainage ditch, there were too few data points to determine the direction of shallow groundwater flow. It is expected that shallow groundwater flows toward the flightline drainage ditch from northwest to southeast on the west side of the ditch. At Building 99 fuel pumping station, the hydraulic gradient was 0.02 ft/ft toward the flightline drainage ditch. At Building 95 fuel pumping station, the hydraulic gradient was approximately 0.025 ft/ft. At Building 93 (former) fuel pumping station, the hydraulic gradient was 0.009 ft/ft.

A slight upward vertical gradient was observed in shallow and deep aquifer well pairs during the investigation. At Building 99, MW-3 and MW-6 are a shallow and deep aquifer well pair in which groundwater elevations were measured. Upward vertical gradients of 0.0007 ft/ft and 0.01 ft/ft were calculated from data collected on October 16, 1995 and November 13, 1995; respectively. Across the flightline drainage ditch from former Building 93, a shallow and deep pair of piezometers was installed. On November 13, 1995; the vertical gradient between the two piezometers was calculated to be 0.005 ft/ft in the upward direction. These measurements suggest that groundwater is under discharging conditions in the vicinities of these two pairs of wells. Both pairs of wells are adjacent to the flightline drainage ditch, suggesting that groundwater flows from the deeper zone to the shallower zone, and probably discharges to the ditch.

Aquifer slug tests were conducted in four wells (MW-3 through MW-6) at Building 99 to estimate aquifer hydraulic conductivity (S&ME, 1993). Hydraulic conductivity values ranged from 2.5×10^{-2} cm/sec (71 ft/day) at MW-3 to 1.7×10^{-4} cm/sec (0.5 ft/day) at well MW-6 (S&ME, 1993). Assuming the effective porosity of the aquifer is 0.3, horizontal groundwater flow velocities were calculated for the three pumping station areas based on hydraulic gradients measured using data from October 16, 1995. At Building 99, the gradient was 0.02 ft/ft, giving an estimated velocity of 4.7 ft/day (1,730 ft/yr). At Building 95, the gradient was 0.025 ft/ft, giving an estimated velocity of 5.9 ft/day (2,160

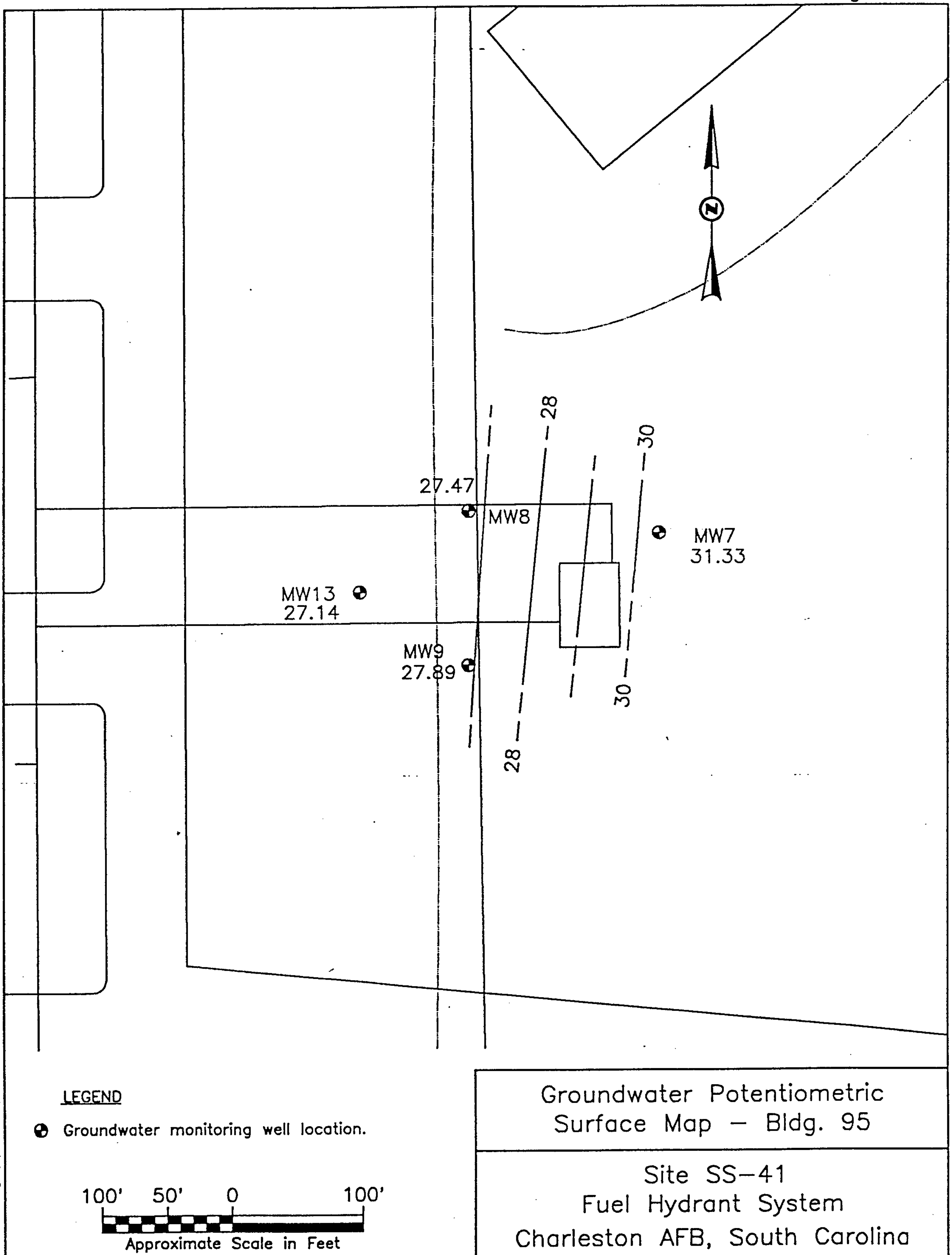
Figure 2.5



Groundwater Potentiometric Surface Map - Bldg. 99

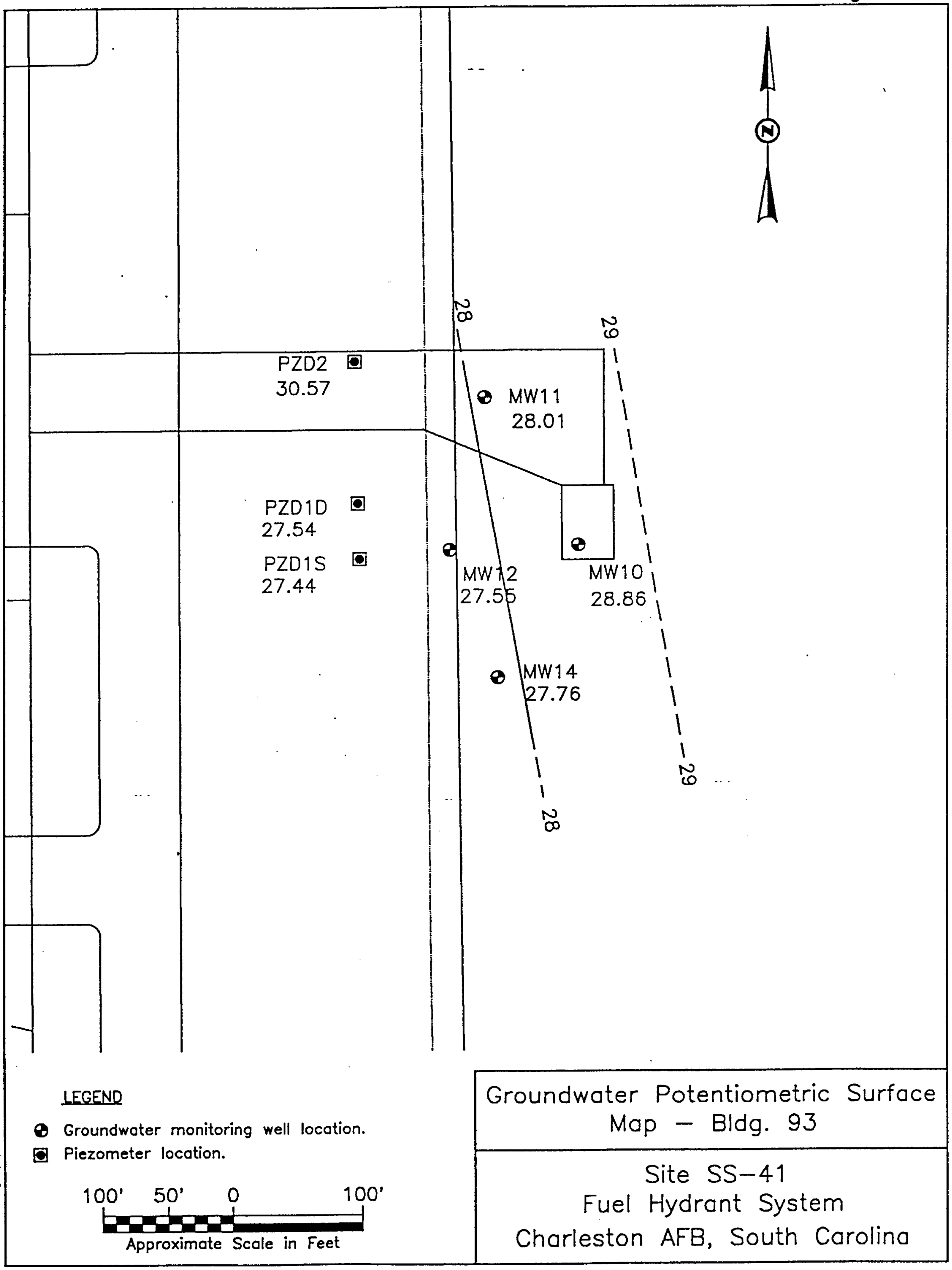
Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

PARSONS ENGINEERING SCIENCE, INC.



Groundwater Potentiometric Surface Map – Bldg. 95

Site SS–41
Fuel Hydrant System
Charleston AFB, South Carolina



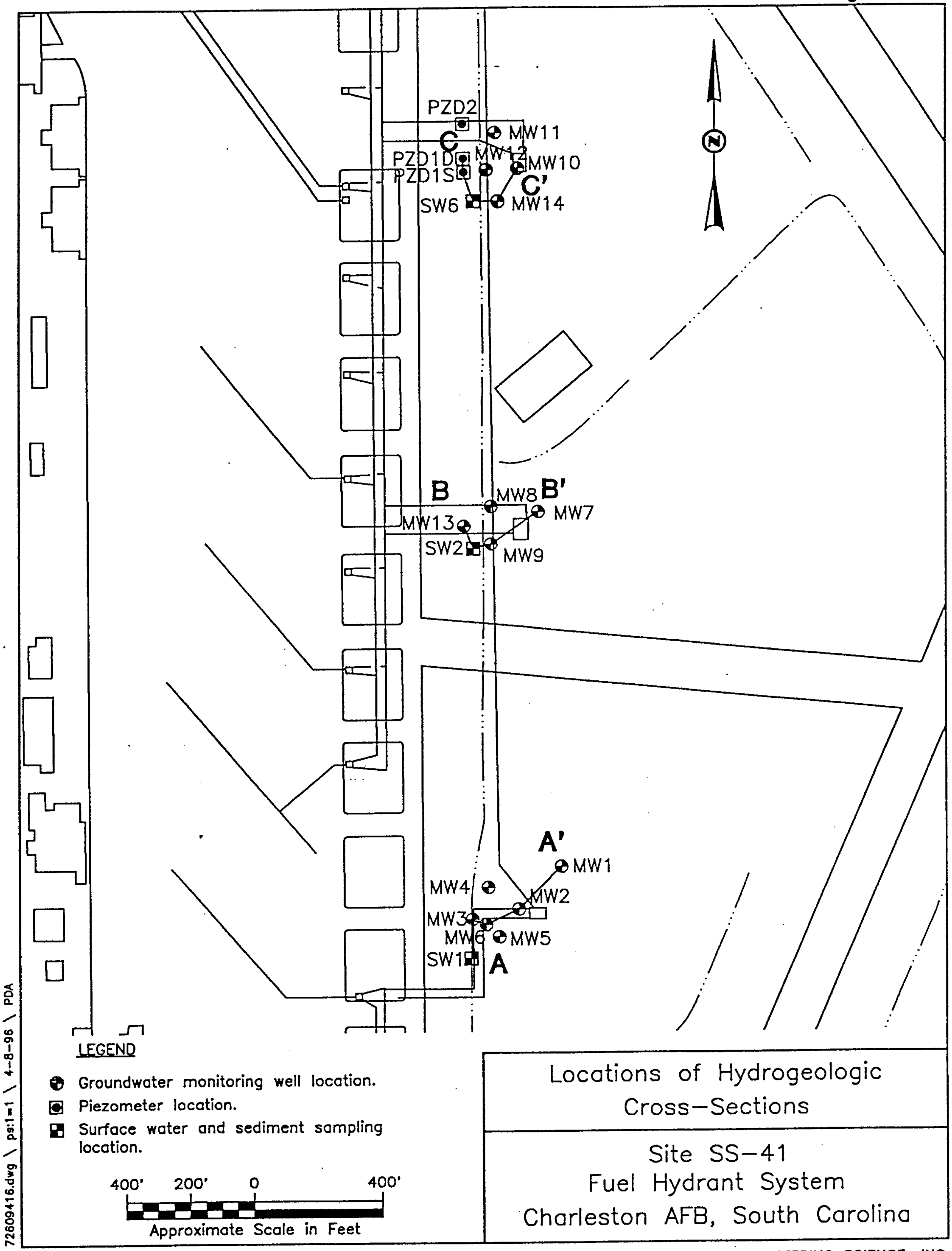
Groundwater Potentiometric Surface Map – Bldg. 93

Site SS–41
Fuel Hydrant System
Charleston AFB, South Carolina

ft/yr). At Building 93, the gradient was 0.009 ft/ft, giving an estimated velocity of 2.1 ft/day (780 ft/yr).

The basewide potentiometric surface map suggests that the overall hydraulic gradient through Site SS-41 is approximately 0.0032 ft/ft (Charleston AFB, February 1994). The overall direction of groundwater flow through Site SS-41 is to the south, which is consistent with the direction of surface water flow in the flightline drainage creek. The groundwater flow velocity through Site SS-41 toward the south, using the gradient measured through Site SS-41, is 0.76 ft/day (277 ft/yr). Based on the shortest distance from Site SS-41 to the closest downgradient base boundary (approximately 4,800 ft to Building 99), it would take a minimum of 17 years for advective groundwater flow to reach the closest downgradient base boundary from Site SS-41.

Figure 2.8 shows locations of hydrogeologic cross-sections through each of the three fuel pumping station areas at Site SS-41. Cross-section A-A', on Figure 2.9, shows the lithology and potentiometric surface through the area around Building 99. Cross-section B-B' (Figure 2.10) shows the lithology and potentiometric surface through the area around Building 95. Figure 2.11 shows hydrogeologic cross-section C-C' through the area around former Building 93.



Locations of Hydrogeologic Cross-Sections

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

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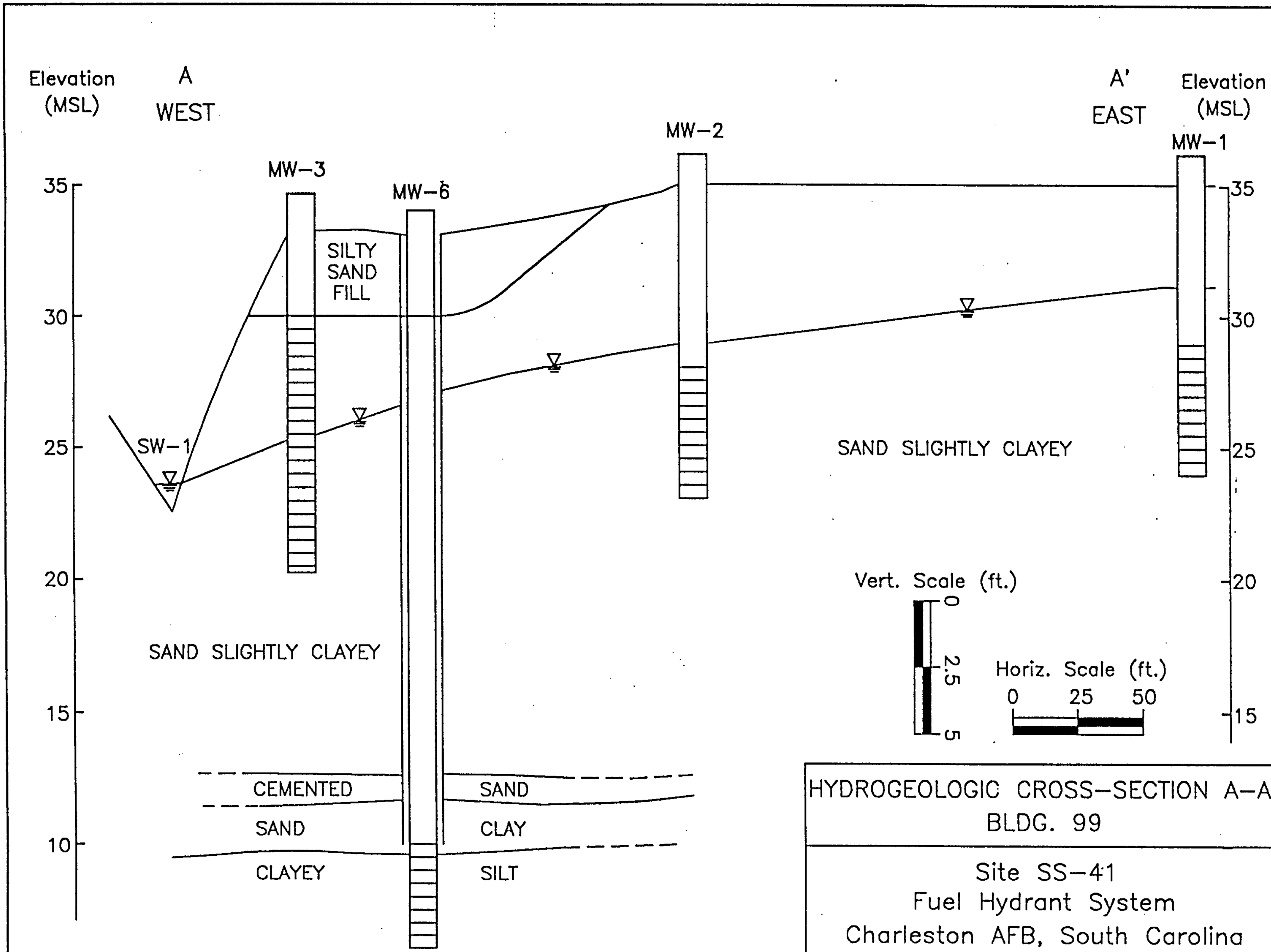

HYDROGEOLOGIC CROSS-SECTION A-A'
BLDG. 99

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

Figure 2.9

Figure 2.10

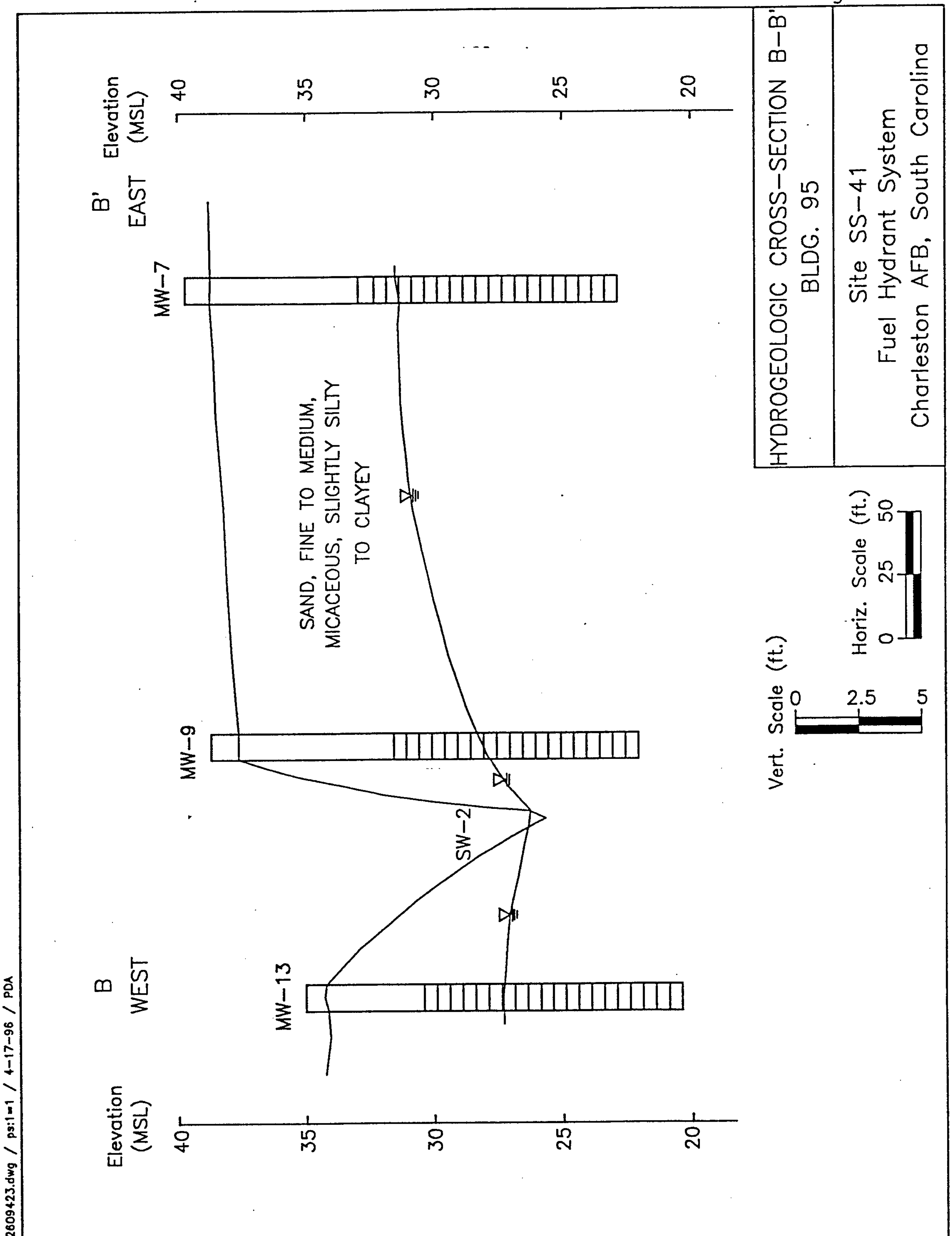
HYDROGEOLOGIC CROSS-SECTION B-B'
BLDG. 95
Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina
B
WEST
B'
EAST
Elevation (MSL)
40
35
30
25
20
MW-13
MW-9
MW-7
SW-2
SAND, FINE TO MEDIUM, MICACEOUS, SLIGHTLY SILTY TO CLAYEY
Vert. Scale (ft.)
0
2.5
5
Horiz. Scale (ft.)
0
25
50
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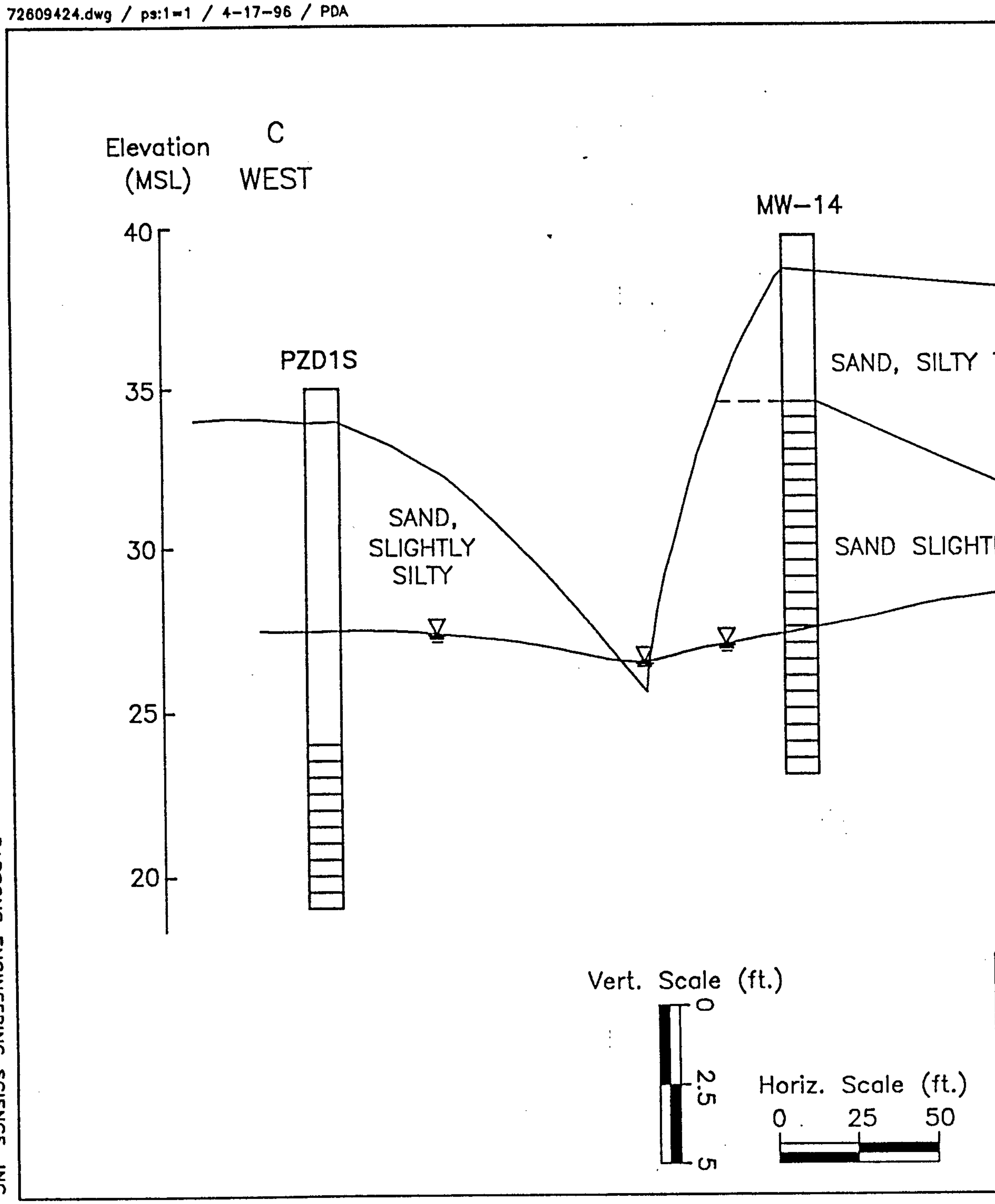
Figure 2.11



HYDROGEOLOGIC CROSS-SECTION C-C'
BLDG. 93

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

3. NATURE AND EXTENT OF CONTAMINANTS OF CONCERN

3.1 SOIL

3.1.1 Building 99 Fuel Pumping Station

No soil samples were collected at Building 99 during this investigation. Soil contaminant data have been collected during previous investigations. Soil, sediment, surface water, and groundwater sampling locations from previous investigations are shown on Figure 3.1. A summary of soil contaminant data is provided in Table 3.1.

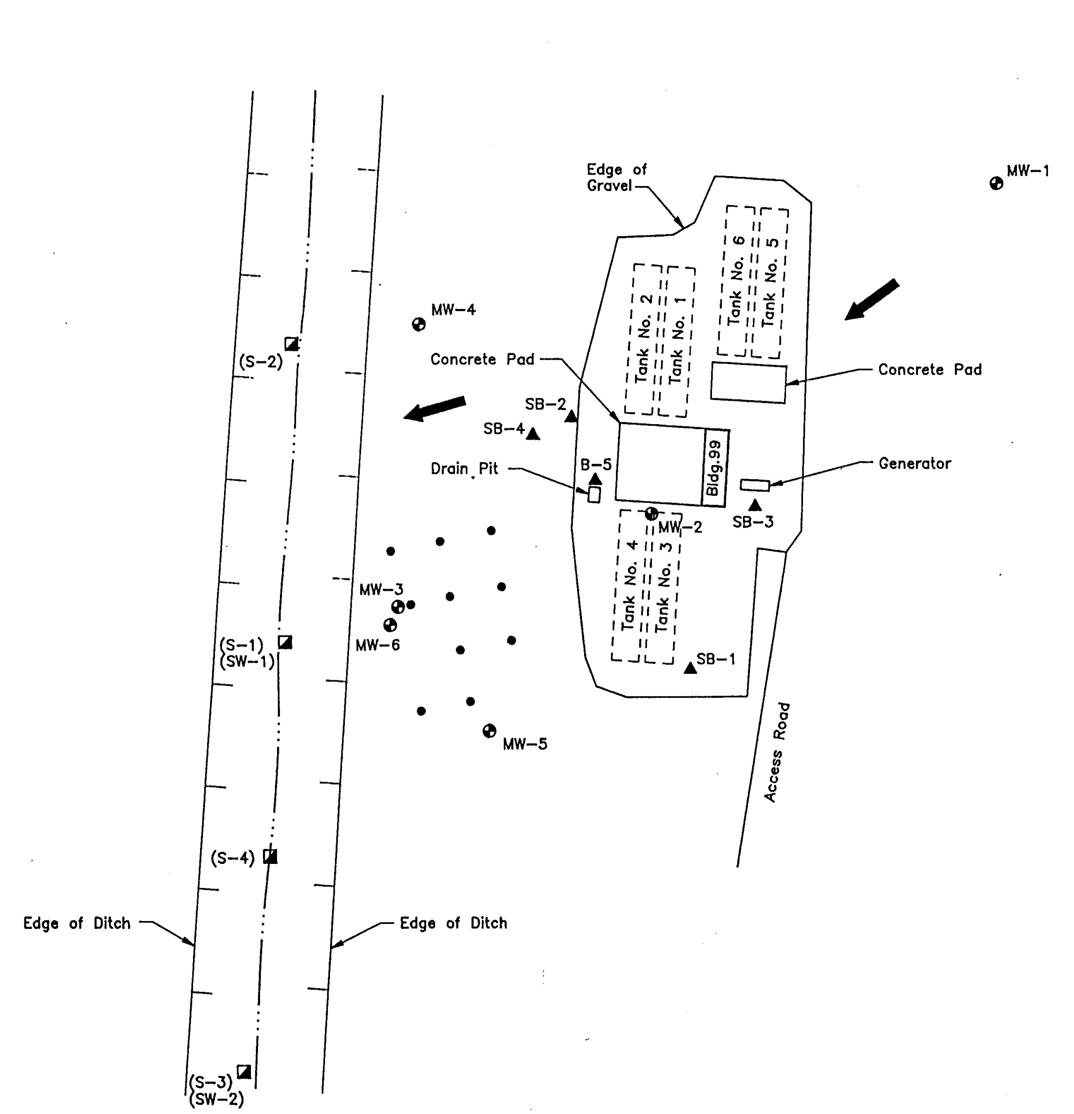
The Air Force collected soil samples at four soil boring locations (SB-1 through SB-4) around Building 99 fuel pumping station, as shown on Figure 3.1. These samples were analyzed for aromatic volatile organic compounds (VOCs) by EPA Method 8020. The VOCs benzene, toluene, and total xylenes were detected in the soil samples. Benzene concentrations ranged from 69.2 milligrams per kilogram (mg/kg) in sample SB-2(S) to 34.4 mg/kg in sample SB-4. Toluene concentrations ranged from 8.2 mg/kg at SB-2 to 2.8 mg/kg at SB-3. The highest concentration of xylenes (16.7 mg/kg) was detected in sample SB-2(S), while samples SB-1 and SB-4 had no detections of xylenes. These results are summarized in Table 3.1.

Twenty-four soil borings were installed by GEL to further assess the extent of soil contamination at Building 99. The soil borings were installed with a hand auger and soil samples were collected and screened for volatile organic vapors using a flame ionization detector (FID). Eight of the twenty-four samples showed positive detections of organic vapors at the water table depth, although all but one of the headspace readings were equal to or less than 50 ppm. GEL collected three soil samples for laboratory analyses of BTEX and TPH from boring B-5 (see Figure 3.1). No BTEX or TPH compounds were detected in any of the three samples from B-5. The laboratory analytical results are summarized in Table 3.1.

3.1.2 Building 95 Fuel Pumping Station

Four soil borings were performed at Building 95 fuel pumping station: SB-1, SB-2, SB-10, and SB-11. The locations of the soil sampling locations at Building 95 were shown previously in Figure 2.3. No soil data had been generated for the area around Building 95 prior to this investigation. Results of soil analyses from this investigation are summarized in Table 3.2. Although analyzed, metals are not considered to be present in soil at Site SS-41 as a result of site activities. Results of metals concentrations are included in Appendix B and are evaluated with respect to risk in Section 4. Five soil samples were analyzed from the four soil borings at Building 95; SB-1 (4 to 6 ft bls), SB-1 (6 to 8 ft bls), SB-2 (6 to 8 ft bls), SB-10 (4 to 6 ft bls), and SB-11 (6 to 8 ft bls). No TPH concentrations were detected in the five soil samples. No semivolatile compounds were detected in the five soil samples. The only volatile compound detected in any of the five soil samples was trichloroethene (TCE). TCE was detected in SB-1 (4-6') at 7.9 micrograms per kilogram (μg/kg), in SB-1 (6-8') at 0.65J μg/kg, in SB-2 (6-8') at 2.2J

Figure 3.1



LEGEND

- MW-1 — Groundwater monitoring well location.
- Groundwater screening sample location.
- Soil boring/sampling location.
- (S-1) — Sediment sample location.
- (SW-1) — Surface water sample location.
- Generalized groundwater flow direction.

NOTES:

1. Generalized groundwater flow direction arrows added by ES as inferred from S&ME data and potentiometric map (1991 data).
2. Groundwater screening sample locations were not surveyed. Sample locations are estimated.
3. Only those soil borings where samples were collected for laboratory analysis are depicted in this figure.

50' 25' 0 50'

Approximate Scale in Feet

Map and Data Sources:
1) General Engineering Laboratories (1990)
2) S&ME, Inc. (1993)

Previous Sampling Locations at Bldg. 99 Fuel Pumping Station

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

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TABLE 3.1
SOIL SAMPLING ANALYTICAL RESULTS
BUILDING 99 FUEL PUMPING STATION
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

Parameter (mg/kg)	Soil Boring/Sampling Location							
	SB-1	SB-2	SB-2(S)	SB-3	SB-4	B-5(1')	B-5(4')	B-5(8')
Benzene	64.2	37.4	69.2	40.8	34.4	<0.010	<0.010	<0.010
1,2-Dichlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	NA	NA	NA
1,3-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
1,4-Dichlorobenzene	<0.7	<0.7	<0.7	<0.7	<0.7	NA	NA	NA
Ethylbenzene	<0.3	<0.3	<0.3	<0.3	<0.3	<0.010	<0.010	<0.010
Toluene	5.0	8.2	5.4	2.8	3.4	<0.010	<0.010	<0.010
Chlorobenzene	<0.6	<0.6	<0.6	<0.6	<0.6	NA	NA	NA
Xylenes	ND	11.7	16.7	4.0	ND	<0.020	<0.020	<0.020
Total Hydrocarbons	NA	NA	NA	NA	NA	<10	<10	<10

ND = Not detected
NA = Not analyzed
mg/kg = milligrams per kilogram (equivalent to parts per million)
Note: Soil borings SB-1 through SB-4 were sampled on 8/17/89.
Soil boring B-5 was sampled on 6/8/90.
Soil samples SB-2 and SB-2(S) are split samples from same sample location.
Data Source: GEL (1990)

TABLE 3.2
SUBSURFACE SOIL ANALYTICAL RESULTS
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

COMPOUND	ID: DEPTH: DATE:	SB-01 04-06' 10/03/95	SB-01-DUP 06-08' 10/03/95	SB-02 06-08' 10/03/95	SB-03 04-06' 10/03/95	SB-04 04-06' 10/04/95	SB-05 04-06' 10/04/95	SB-06 04-06' 10/04/95	SB-07 04-06' 10/04/95	SB-08 04-06' 10/04/95	SB-09 06-08' 10/04/95	SB-10 04-06' 10/04/95	SB-11 06-08' 10/04/95
VOLATILES	UNITS:												
Benzene	µg/Kg	5.7 U	5.5 U	6.2 U	1.7 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Ethylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	17	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Isopropylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	2 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Naphathalene	µg/Kg	5.7 U	5.5 U	6.2 U	25	0.8 J	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
1,1,2,2-Tetrachloroethane	µg/Kg	5.7 U	5.5 U	6.2 U	1.1 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Toluene	µg/Kg	5.7 U	5.5 U	6.2 U	2.7 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
1,2,4-Trichlorobenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	0.7 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
1,1,1-Trichloroethane	µg/Kg	5.7 U	5.5 U	6.2 U	1.3 J	1.9 J	5.6 U	2.1 J	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Trichloroethene	µg/Kg	7.9	0.65 J	2.2 J	7.9	9.9	8.2	18	4.3 J	14	4.2 J	5.5 U	1.3 J
1,2,4-Trimethylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	34	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
1,3,5-Trimethylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	43	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
m,p-Xylene	µg/Kg	5.7 U	5.5 U	6.2 U	110	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
n-Butylbenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	1.1 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
n-Propylbenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	0.63 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
o-Xylene	µg/Kg	5.7 U	5.5 U	6.2 U	56	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
p-Isopropyltoluene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 J	6.4 U	0.68 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
sec-Butylbenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	0.64 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
tert-Butylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	2.7 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
SEMIVOLATILES													
Benzo(a)anthracene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	790 J	850 U	810 U	730 U	1000 U
Benzo(a)pyrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	850 J	850 U	810 U	730 U	1000 U
Benzo(b)fluoranthene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	170 J	1400 J	850 U	810 U	730 U	1000 U
Benzo(ghi)perylene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	800 J	850 U	810 U	730 U	1000 U
Benzo(k)fluoranthene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	500 J	850 U	810 U	730 U	1000 U
Chrysene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	1000 J	850 U	810 U	730 U	1000 U
Fluoranthene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	1800	850 U	810 U	730 U	1000 U
Indeno(1,2,3-cd)pyrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	870 J	850 U	810 U	730 U	1000 U
Phenanthrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	990 J	850 U	810 U	730 U	1000 U
Pyrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	210 J	1900	850 U	810 U	730 U	1000 U
bis(2-ethylhexyl)phthalate	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	530 J	850 U	810 U	730 U	1000 U
OTHER													
TPH-JP4	mg/Kg	11 U	11 U	12 U	44 J	13 U	11 U	11 U	16	13 U	12 U	11 U	15 U
TKN	mg/Kg	87	46	340	260	370	160	200	470	49	96	33	110
Total Phosphorus	mg/Kg	35	21	91	62	53	61	120	190	33	45	18	50
Solids, Percent	%	87.6	91.1	80.3	81.5	78.7	89.2	89.7	85.2	78	81	90.4	65.5
pH	PH UNITS	4.9	5.8	5.2	4.6	4.3	4.9	6.8	8	4.8	5.3	6.1	5.1

U = Not detected.

J = Estimated value.

μg/kg, and in SB-11 (6-8') at 1.3J μg/kg ("J" is the data validation flag for estimated value).

3.1.3 Building 93 Fuel Pumping Station

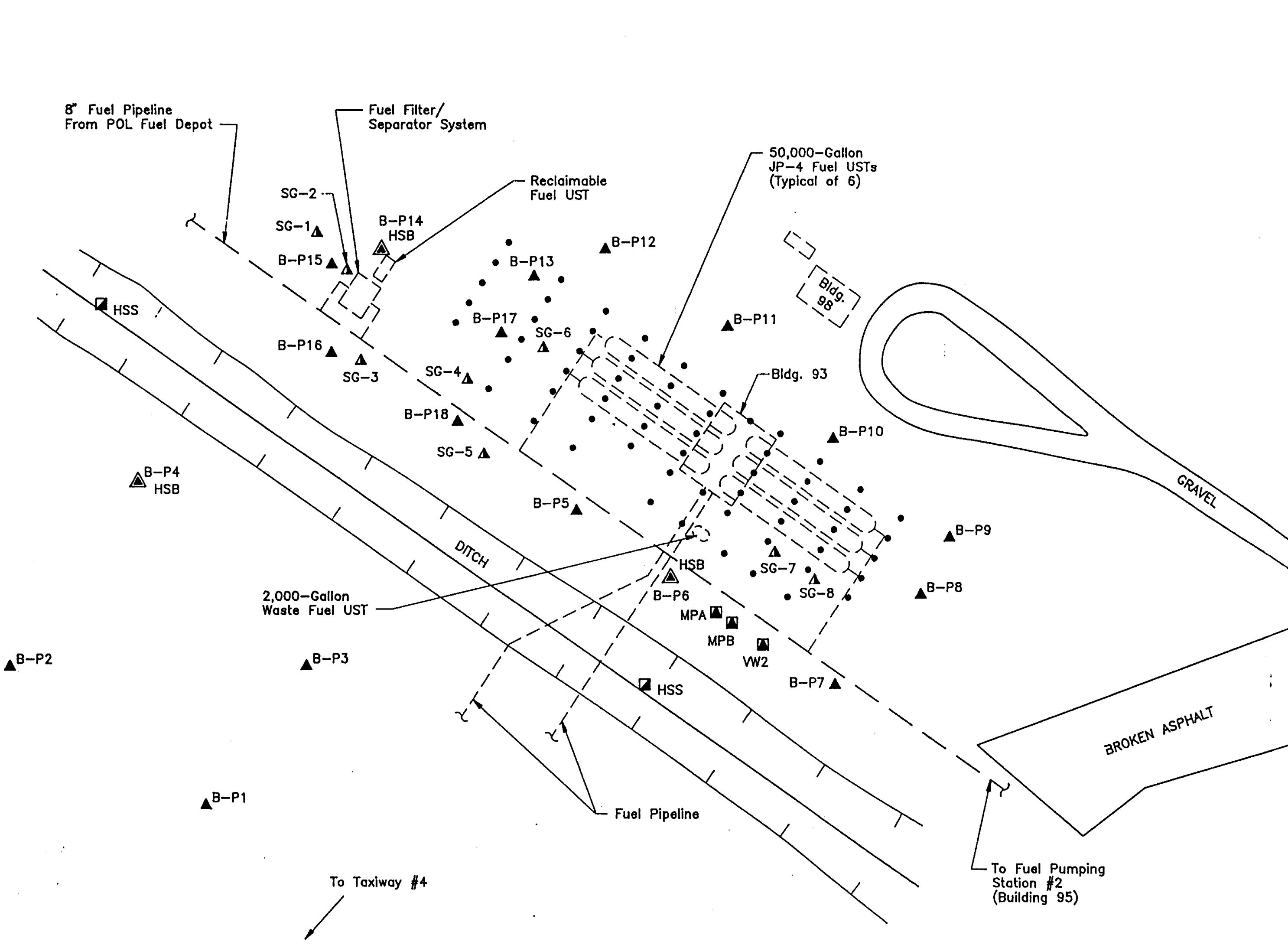
Westinghouse advanced eighteen soil borings around Building 93 and collected soil samples for PID headspace screening and laboratory BTEX analysis. Figure 3.2 shows the locations of the soil borings. Soil samples were collected at the saturated zone of the water table interface as a qualitative indicator of potential groundwater contamination. BTEX compounds were detected in nine of the soil samples. The greatest concentration of BTEX was detected at soil boring B-P14, located north of former Building 93 adjacent to the former fuel filter/separator system and reclaimable fuels UST (see Figure 3.2). The following soil BTEX concentrations were detected at B-P14: benzene (10 mg/kg); toluene (8.8 mg/kg); ethylbenzene (13 mg/kg); and xylenes (50 mg/kg). Westinghouse reported the presence of "free product" at soil boring B-P14 based on the observation of an oily sheen on the saturated soil sample. Table 3.3 summarizes these results.

Additional non-IRP soil sampling was performed by Coastal Engineering and Testing, Inc. in September 1993, prior to and during the UST removals. Soil samples were collected around and beneath the USTs in a grid pattern, as shown in Figure 3.2. The samples were analyzed for various parameters including TPH, BTEX, and naphthalene. Several additional samples were analyzed for jet fuel fraction hydrocarbons and RCRA metals. BTEX compounds were detected in 47 soil samples collected around the former USTs. Soil BTEX concentrations varied widely with sample location and depth. The highest detected benzene concentration was 7.4 mg/kg at a depth of 4 feet bls and the highest naphthalene concentration was 37.2 mg/kg. Detectable soil TPH concentrations ranged from 2.4 mg/kg to 1,180 mg/kg. Jet fuel hydrocarbon concentrations ranged from less than 10 mg/kg to 24,000 mg/kg. Detected RCRA metals and the highest concentration include: arsenic (20 mg/kg), barium (110 mg/kg), cadmium (1 mg/kg), chromium (10 mg/kg), lead (30 mg/kg), mercury (0.1 mg/kg), selenium (20 mg/kg), and silver (4 mg/kg). These results are not included in Table 3.3 because a published report of the sampling results was not available to Parsons ES and some of the laboratory data are reported as preliminary results.

Three soil samples were collected and analyzed as part of the bioventing pilot study at former Building 93 fuel pumping station. These sample locations are designated as VW2, MPA, and MPB on Figure 3.2. The sample depths were above the water table and averaged 7.5 to 8 feet bls. Benzene was not detected in any of the samples, although ethylbenzene, toluene, and xylenes were detected. TRPH concentrations ranged from 241 mg/kg to 1,400 mg/kg (see Table 3.3). Three soil gas samples were quantitatively analyzed for BTEX and TVH. Benzene was not detected in soil gas, however TVH concentrations of 21,000 ppmv were detected at VW2 and MPC. The soil gas analytical results are found in Table 3.3.

Seven soil borings were performed at the fuel pumping station at Building 93 during this investigation: SB-3, SB-4, SB-5, SB-6, SB-7, SB-8, and SB-9. The soil sampling locations at Building 93 were shown previously in Figure 2.3. A summary of the soil data collected during the investigation at Building 93 is shown in Table 3.2. Although

Figure 3.2



LEGEND

- HSS — Halliburton surface water and sediment sample location.
- HSB — Halliburton soil boring/sample location.
- B-P15 — Westinghouse soil boring.
- SG-1 — ES exploratory soil gas point.
- MPA — ES soil boring/sampling point.
- • — Coastal Engineering soil boring/sampling point.

NOTES:

1. All above-grade and below-grade structures and USTs (except the primary 8" fuel pipeline) were removed in 1993.
2. All facility and appurtenance locations are approximated.
3. All environmental sampling locations are approximated.

60' 40' 20' 0 60'
Approximate Scale in Feet

Map and Data Sources:
1) Westinghouse (1991)
2) Coastal Engineering (1993)
3) Engineering-Science, Inc. (1993)
4) Halliburton NUS Corp. (1993)

Previous Sampling Locations at Bldg. 93 Fuel Pumping Station

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

PARSONS ENGINEERING SCIENCE, INC.

72609404.dwg / ps:1=1 / 4-4-96 / PDA

TABLE 3.3
SOIL AND SOIL GAS ANALYTICAL RESULTS
BUILDING 93 FUEL PUMPING STATION AND VICINITY
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

SOIL MATRIX

Boring/ Sample No.	Laboratory Analytical Results (mg/kg)					Headspace PID/OVA Reading (ppmv)
	Benzene	Ethylbenzene	Toluene	Xylenes	TRPH	
B-P4	4.3	3.5	4.0	15	NA	1011
B-P5	0.011	0.0075	0.010	0.049	NA	1271
B-P6	0.30	0.39	0.23	1.1	NA	197
B-P7	0.033	0.0042	0.0039	0.0013	NA	106
B-P8	ND	ND	ND	ND	NA	0
B-P9	ND	ND	ND	ND	NA	54.8
B-P10	ND	ND	ND	ND	NA	5.3
B-P11	ND	ND	ND	ND	NA	5.5
B-P12	ND	ND	ND	ND	NA	5
B-P13	0.0059	ND	0.0063	0.0066	NA	68
B-P14	10.0	13.0	8.8	50.0	NA	FP
B-P15	ND	ND	0.0018	0.0027	NA	2.7
B-P16	0.0031	0.0016	ND	0.006	NA	16
B-P17	ND	ND	ND	ND	NA	26
B-P18	ND	ND	0.078	ND	NA	3311
VW2-8	ND	2.8	23	19	544	4,500
MPA-7.5	ND	ND	46	17	241	6,100
MPB-7.5	ND	2.9	14	16	1,400	7,100

Data Sources: Westinghouse (1991); ES (1994)
ND = not detected
mg/kg = milligrams per kilogram (equivalent to parts per million)
ppmv = parts per million by volume
NA = not analyzed
TRPH = total recoverable petroleum hydrocarbons (EPA Method 418.1)
FP = free product

SOIL GAS MATRIX

Sample Location-Depth	Laboratory Analytical Results (ppmv)					OVA Field Readings (ppmv)
	Benzene	Ethylbenzene	Toluene	Xylenes	TVH	
VW2-8	ND	5.9	ND	8.1	21,000	>20,000
MPC-8	ND	5.3	ND	11.5	21,000	>20,000
MPD-8	ND	3.4	ND	9.9	17,000	8,000

Data Source: ES (1994)
TVH = total volatile hydrocarbons
ND = not detected
ppmv = parts per million by volume
OVA = organic vapor analyzer (GasTech total hydrocarbon analyzer)

NOTE: Soil gas samples were collected directly from permanent vapor monitoring points.

analyzed, metals are not considered to be present in soil at Site SS-41 as a result of site activities. Results of metals concentrations are included in Appendix B and are evaluated with respect to risk in Section 4. TCE was detected in all of the soil samples collected at Building 93, ranging in concentration from 4.2J µg/kg (SB-9) to 18J µg/kg (SB-6). In SB-3, volatile compounds detected included benzene at 1.7J µg/kg; ethylbenzene at 17 µg/kg; isopropylbenzene at 2J µg/kg; naphthalene at 25 µg/kg; 1,1,2,2-tetrachloroethane at 1.1J µg/kg; toluene at 2.7J µg/kg; 1,1,1-trichloroethane at 1.3J µg/kg; 1,2,4-trimethylbenzene at 34 µg/kg; 1,3,5-trimethylbenzene at 43 µg/kg; m,p-xylene at 110 µg/kg; o-xylene at 56 µg/kg; p-isopropyltoluene at 6.1 µg/kg; and tert-butylbenzene at 2.7J µg/kg. In SB-4, volatile compounds detected included naphthalene at 0.8J µg/kg and 1,1,1-trichloroethane at 1.9J µg/kg. In SB-5, volatile compounds detected included 1,2,4-trichlorobenzene at 0.7J µg/kg; n-butylbenzene at 1.1J µg/kg; n-propylbenzene at 0.63J µg/kg; p-isopropyltoluene at 0.68J µg/kg; and sec-butylbenzene at 0.64J µg/kg. In SB-6, volatile compounds included 1,1,1-trichloroethane at 2.1J µg/kg. In SB-7, SB-8, and SB-9 no volatile compounds with the exception of TCE were detected.

No semivolatile compounds were detected in SB-3, SB-4, SB-5, SB-8, and SB-9. In SB-6, benzo(b)fluoranthene was detected at 170J µg/kg and pyrene was detected at 210 µg/kg. In SB-7, semivolatile compounds detected included benzo(a)anthracene at 790J µg/kg; benzo(a)pyrene at 850J µg/kg; benzo(b)fluoranthene at 1400J µg/kg; benzo(ghi)perylene at 800J µg/kg; benzo(k)fluoranthene at 500J µg/kg; chrysene at 1,000J µg/kg; fluoranthene at 1,800 µg/kg; indeno(1,2,3-cd)pyrene at 870J µg/kg; phenanthrene at 990J µg/kg; pyrene at 1,900 µg/kg; and bis(2-ethylhexyl)phthalate at 530J µg/kg. TPH (JP-4) was detected in SB-3 and SB-7 at concentrations of 44J mg/kg and 16 mg/kg, respectively. No other soil samples indicated TPH (asJP-4) above laboratory detection limits.

3.2 GROUNDWATER

As described in Section 2.3, two groundwater sampling events were performed during this investigation. A summary of the groundwater analytical results for the October 1995 sampling event is presented in Table 3.4. A summary of the groundwater analytical results for the November 1995 sampling event is presented in Table 3.5. Although analyzed, metals are not considered to be present in groundwater at Site SS-41 as a result of site activities. Results of metals concentrations are included in Appendix B and are evaluated with respect to risk in Section 4.

3.2.1 Building 99 Groundwater Quality

Data from the October 1995 sampling event are summarized in Table 3.4. Of the six monitoring wells at Building 99, volatile and/or semivolatile compounds were detected in only two wells. In MW-3, benzene was detected at 9.3 µg/l; ethylbenzene was detected at 0.77J µg/l; isopropylbenzene was detected at 0.92J µg/l; naphthalene was detected at 1.2 µg/l; m,p-xylene was detected at 0.63 µg/l; and phenol was detected at 2.5J µg/l. In MW-4, toluene was detected at 1.1 µg/l and TCE was detected at 1.7 µg/l.

TABLE 3.4
GROUNDWATER ANALYTICAL RESULTS
FIRST ROUND - OCTOBER 1995
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

COMPOUND	ID: / DATE:	MW-1 10/16/95	MW-1-DUP 10/18/95	MW-3 10/16/95	MW-4 10/16/95	MW-5 10/16/95	MW-6 10/16/95	MW-7 10/17/95	MW-8 10/17/95	MW-9 10/17/95	MW-10 10/18/95	MW-11 10/18/95	MW-12 10/18/95	MW-13 10/17/95	MW-14 10/18/95
VOLATILES	UNITS:														
Benzene	µg/L	1 U	1 U	9.3	1 U	1 U	1 U	1 U	2.1	1 U	1 U	86	1 U	1 U	1 U
Ethylbenzene	µg/L	1 U	1 U	0.77 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U	25	1 U	1 U	1 U
Isopropylbenzene	µg/L	1 UJ	1 U	0.92 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Naphathalene	µg/L	1 U	1 U	1.2	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.3	1 U	1 U	1 U
Toluene	µg/L	1 U	1 U	1 U	1.1	1 U	1 U	1 U	1 U	1 U	1 U	84	1 U	1 U	1 U
Trichloroethene	µg/L	1 U	1 U	1 U	1.7	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
m,p-Xylene	µg/L	2 U	2 U	0.63 J	2 U	2 U	2 U	2 U	2 U	2 U	2 U	98	2 U	2 U	2 U
n-Butylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1.8	1 U	1 U	1 U
o-Xylene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	90	1 U	1 U	1 U
p-Isopropyltoluene	µg/L	1 U	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 U	1 U	1 U	1 UJ	2.2 J	1 UJ	1 U	1 UJ
SEMIVOLATILES															
Phenol	µg/L	10 U	10 U	2.5 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	13	10 U	10 U	10 U
bis(2-ethylhexyl)phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	16	10 U	1.7 J	10 U	2.1 J	10 U	10 U	10 U
OTHER															
TPH-JP4	µg/L		100 UJ			100 UJ						4800 J	100 UJ		
Methane	mg/L	12	29	1100	12	11	12	12	120	12	5.6 U	430	31	500	20
Nitrogen, Nitrate-Nitrite	µg/L	20	20	70	910	30	110	20	8 U	10	50	20	10	30	20
Sulfate	mg/L	5	14	5	3	8	5	15	14	9	39	13	9	7	11

U = Not detected.

J = Estimated value.

TABLE 3.5
GROUNDWATER ANALYTICAL RESULTS
SECOND ROUND - NOVEMBER 1995
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

COMPOUND	ID: DATE:	MW-1 11/13/95	MW-1-DUP 11/14/95	MW-3 11/13/95	MW-4 11/13/95	MW-5 11/13/95	MW-6 11/13/95	MW-7 11/14/95	MW-8 11/14/95	MW-9 11/14/95	MW-10 11/15/95	MW-11 11/14/95	MW-12 11/14/95	MW-13 11/14/95	MW-14 11/14/95
VOLATILES	UNITS:														
Benzene	µg/L	1 U	1 U	3	1 U	1 U	1 U	1 U	1.9 J	1 U	1 U	2 J	1 U	1 U	1 U
Chlorobenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.46 J	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 J	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	µg/L	1 U	1 U	0.92 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.9 J	1 U	1 U	1 U
Toluene	µg/L	1 U	1 U	1 U	1 U	0.63 J	1 U	1 U	0.74 J	1 U	1 U	1.8 J	1 U	1 U	1 U
m,p-Xylene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	10	1 U	1 U	1 U
o-Xylene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	3	1 U	1 U	1 U
SEMIVOLATILES															
Di-n-butyl phthalate	µg/L	2.1 J	10 U	10 U	10 U	10 U	3.2 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-ethylhexyl)phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	1.5 J	1.1 J	2.5 J	10 U	6 J	2.3 J	10 U	10 U
OTHER															
TPH-JP4	µg/L		380 J			100 UJ						620 J	430 J		
Nitrogen, Nitrate-Nitrite	µg/L	18	13	99	860	73	93	20	9.7	8 U	8.1	19	9.9	8 U	11
Sulfate	mg/L	4	7.8	5.6	4.2	9.1	6	8.6	8.3	7.4	68	6.9	7.1	3.4	9.3

U = Not detected.
J = Estimated value.

Data from the November 1995 sampling event are summarized in Table 3.5. Only monitoring wells MW-1, MW-3, MW-5, and MW-6 indicated detections of volatile and/or semivolatile compounds. In MW-1, di-n-butyl phthalate was detected at a concentration of 2.1J µg/l. Benzene was detected in MW-3 at 3 µg/l and ethylbenzene was detected at 0.92J µg/l. Toluene was detected in MW-5 at 0.63J µg/l. In MW-6, di-n-butyl phthalate was detected at a concentration of 3.2J µg/l.

3.2.2 Building 95 Groundwater Quality

Data from the October 1995 groundwater sampling event indicated detections of volatile compounds in MW-8 only (see Table 3.4). Detections of semivolatile compounds were indicated in MW-7 and MW-9. Benzene was detected in MW-8 at a concentration of 2.1 µg/l. Bis (2-ethylhexyl) phthalate was detected in MW-7 at 16 µg/l and in MW-9 at 1.7 µg/l.

Data from the November 1995 groundwater sampling event indicated detections of volatile and/or semivolatile compounds in monitoring wells MW-7, MW-8, and MW-9 at Building 95 (see Table 3.5). MW-8 was the only monitoring well in which volatile compounds were detected from the November 1995 groundwater sampling event. Volatile compounds detected in MW-8 included benzene at 1.9J µg/l, chlorobenzene at 0.46J µg/l, chloromethane at 2J µg/l, and toluene at 0.74J µg/l. Bis (2-ethylhexyl) phthalate was detected in MW-7 at 1.5J µg/l, in MW-8 at 1.1J µg/l, and in MW-9 at 2.5J µg/l.

3.2.3 Building 93 Groundwater Quality

Data from the October 1995 groundwater sampling event indicated concentrations of volatile and semivolatile compounds were detected only in monitoring well MW-11 (see Table 3.4). Benzene was detected at 86 µg/l; ethylbenzene was detected at 25 µg/l; naphthalene was detected at 2.3 µg/l; toluene was detected at 84 µg/l; m,p-xylene was detected at 98 µg/l; n-butylbenzene was detected at 1.8 µg/l; o-xylene was detected at 90 µg/l; p-isopropyltoluene was detected at 2.2J µg/l; phenol was detected at 13 µg/l; and bis (2-ethylhexyl) phthalate was detected at 2.1J µg/l. In addition, TPH (JP-4) was detected at a concentration of 4,800J µg/l in MW-11.

Data from the November 1995 groundwater sampling event indicated detections of volatile and/or semivolatile compounds in monitoring wells MW-11 and MW-12 at Building 93 (see Table 3.5). In MW-11, benzene was detected at 2J µg/l; ethylbenzene was detected at 2.9J µg/l; toluene was detected at 1.8J µg/l; m,p-xylene was detected at 10 µg/l; o-xylene was detected at 3 µg/l; and bis (2-ethylhexyl) phthalate was detected at 6J µg/l. Bis (2-ethylhexyl) phthalate was detected at 2.3J µg/l in MW-12. In addition, TPH (JP-4) was detected at concentrations of 620J µg/l and 430J µg/l in MW-11 and MW-12, respectively.

3.3 SURFACE WATER AND SEDIMENT

3.3.1 Surface Water Quality

As shown previously in Figure 2.4, surface water and sediment samples were collected from six locations along the flightline drainage ditch during this investigation. As shown by groundwater elevation data (see Section 2.5), the groundwater discharges to the drainage ditch from both sides. Two sampling points, SW-4 and SW-5, are hydraulically upstream of the three fuel pumping stations at Site SS-41. Surface water and sediment quality from these locations was analyzed to provide uparadient "background" data for comparison to samples collected near the fuel pumping stations. Table 3.6 and Table 3.7 summarize the surface water and sediment data, respectively, collected during this investigation. Although analyzed, metals are not considered to be present in surface water at Site SS-41 as a result of site activities. Results of metals concentrations are included in Appendix B and are evaluated with respect to risk in Section 4.

No volatile or semivolatile compounds were detected in upstream surface water samples at SW-4 and SW-5. TPH (JP-4) concentrations detected at SW-4 and SW-5 were 290J µg/l and 160J µg/l, respectively. Surface water collected at SW-6, adjacent to Building 93, indicated no detections of volatile or semivolatile compounds or TPH (JP-4).

Surface water samples were collected from the ditch adjacent to Building 95 at SW-2 and SW-3. Ethylbenzene was detected at SW-2 at a concentration of 1.1 µg/l. At SW-3, m,p-xylene was detected at 1.2J µg/l.

SW-1 represents the sample collection point farthest downstream at Site SS-41. No volatile or semivolatile compounds were detected in sample SW-1. In the duplicate surface water sample collected at SW-1, several semivolatile compounds were indicated. Benzo(a)pyrene was detected at 1.4J µg/l, benzo(b)fluoranthene was detected at 2.6J µg/l, chrysene was detected at 1.9J µg/l, fluoranthene was detected at 4.3J µg/l, phenanthrene was detected at 2.2J µg/l, pyrene was detected at 3.6J µg/l, and bis(2-ethylhexyl)phthalate was detected at 6J µg/l. In addition, TPH (JP-4) was detected in the duplicate at SW-1 at 570 J µg/l.

3.3.2 Sediment Quality

Table 3.7 summarizes the laboratory results of sediment sample analyses from Site SS-41. Although analyzed, metals are not considered to be present in sediment at Site SS-41 as a result of site activities. Results of metals concentrations are included in Appendix B and are evaluated with respect to risk in Section 4. At the upstream sediment sampling locations, SS-4 and SS-5, no semivolatile compounds were detected. TCE was detected at SS-4 at 2.9J µg/kg. At SS-5, toluene was detected at 0.3J µg/kg, TCE was detected at 0.86J µg/kg, and m,p-xylene was detected at 0.4J µg/kg. In addition, TPH (JP-4) was detected at SS-5 at 18 mg/kg.

At SS-6, adjacent to Building 93, TCE was detected at 5.2J µg/kg, benzo(b)fluoranthene was detected at 1,040J µg/kg, benzo(ghi)perylene was detected at

TABLE 3.6
SURFACE WATER ANALYTICAL RESULTS
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

COMPOUND	ID: DATE:	SW-1 10/03/95	SW-1-DUP1 10/03/95	SW-1-DUP2 10/03/95	SW-2 10/03/95	SW-3 10/03/95	SW-4 10/03/95	SW-5 10/03/95	SW-6 10/03/95
VOLATILES	UNITS:								
Ethylbenzene	µg/L	1 U	1 U	1 U	1.1	1 U	1 U	1 U	1 U
1,1,1-Trichloroethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	R	1 U
m,p-Xylene	µg/L	2 U	2 U	2 U	2 U	1.2 J	2 U	2 U	2 U
SEMIVOLATILES									
Benzo(a)pyrene	µg/L	10 U	1.4 J	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	µg/L	10 U	2.6 J	10 U	10 U	10 U	10 UJ	10 U	10 U
Benzyl alcohol	µg/L	20 U	20 U	20 U	20 U	20 U	R	20 U	20 U
4-Chloro-3-methylphenol	µg/L	20 U	20 U	20 U	20 U	20 U	R	20 U	20 U
2-Chlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
Chrysene	µg/L	10 U	1.9 J	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butyl phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
2,4-Dimethylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
4,6-Dinitro-2-methylphenol	µg/L	50 U	50 U	50 U	50 U	50 U	R	50 U	50 U
2,4-Dinitrophenol	µg/L	50 U	50 U	50 U	50 U	50 U	R	50 U	50 U
Fluoranthene	µg/L	10 U	4.3 J	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
4-Methylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
2-Nitrophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
4-Nitrophenol	µg/L	50 UJ	50 U	50 UJ	50 UJ	50 UJ	R	50 UJ	50 UJ
Pentachlorophenol	µg/L	50 U	50 U	50 U	50 U	50 U	R	50 U	50 U
Phenanthrene	µg/L	10 U	2.2 J	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
Pyrene	µg/L	10 U	3.6 J	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
2,4,5-Trichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
bis(2-ethylhexyl)phthalate	µg/L	10 U	6 J	10 U	10 U	10 U	10 U	10 U	10 U
SEMIVOLATILE TICs									
Unknown Alkane (15.89)	µg/L		11 J						
Unknown Alkane (16.18)	µg/L		13 J						
Unknown Alkane (16.31)	µg/L		9.3 J						
Unknown Alkane (16.54)	µg/L		23 J						
OTHER									
TPH-JP4	µg/L	100 UJ	570 J	110 J	100 UJ	100 UJ	290 J	160 J	100 UJ
Nitrogen, Nitrate-Nitrite	µg/L	110		10	20	30	8 U	20	10
Sulfate	mg/L	10		10	14	16	9	10	9

U = Not detected.
J = Estimated value.

TABLE 3.7
SEDIMENT ANALYTICAL RESULTS
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

COMPOUND	ID: DATE:	SS-1 10/03/95	SS-2 10/04/95	SS-2-DUP 10/03/95	SS-3 10/04/95	SS-4 10/04/95	SS-5 10/04/95	SS-6 10/04/95
VOLATILES	UNITS:							
Methylene chloride	µg/Kg	6.6 U	6.4 U	2.6 J	6.4 U	6.6 U	6.6 U	6.4 U
Toluene	µg/Kg	6.6 U	6.4 U	6.2 U	6.4 U	6.6 U	0.3 J	6.4 U
Trichloroethene	µg/Kg	1.2 J	1.2 J	1.1 J	4.2 J	2.9 J	0.86 J	5.2 J
Trichlorofluoromethane	µg/Kg	6.6 U	6.4 U	9.1	6.4 U	6.6 U	6.6 U	6.4 U
m,p-Xylene	µg/Kg	6.6 U	6.4 U	6.2 U	6.4 U	6.6 U	0.4 J	6.4 U
SEMIVOLATILES								
Benzo(a)anthracene	µg/Kg	310 J	700 J	320 J	680 J	870 UJ	870 U	850 UJ
Benzo(a)pyrene	µg/Kg	330 J	550 J	250 J	640 J	870 UJ	870 U	850 UJ
Benzo(b)fluoranthene	µg/Kg	500 J	850	350 J	960	870 UJ	870 U	1040 J
Benzo(ghi)perylene	µg/Kg	310 J	380 J	820 U	540 J	870 UJ	870 U	780 J
Benzo(k)fluoranthene	µg/Kg	870 U	260 J	820 U	360 J	870 UJ	870 U	850 UJ
Chrysene	µg/Kg	400 J	710 J	320 J	750 J	870 UJ	870 U	840 J
Fluoranthene	µg/Kg	840 J	1500	910	1600	870 U	870 U	1540 J
Indeno(1,2,3-cd)pyrene	µg/Kg	350 J	430 J	820 U	610 J	870 UJ	870 U	850 UJ
Phenanthrene	µg/Kg	360 J	600 J	700 J	960	870 U	870 U	960 J
Pyrene	µg/Kg	650 J	1300	700 J	1400	870 UJ	870 U	2000 J
OTHER								
TPH-JP4	mg/Kg	13	15 J	12	20 J	13 U	18	17
Solids, Percent	%	76	78.4	80.2	78.4	75.8	75.7	78.1

780J µg/kg, chrysene was detected at 840J µg/kg, fluoranthene was detected at 1,540J µg/kg, phenanthrene was detected at 960J µg/kg, and pyrene was detected at 2,000J µg/kg. In addition, TPH (JP-4) was detected in SS-6 at 17 mg/kg.

Sediment samples SS-2 and SS-3 were collected from the flightline drainage ditch adjacent to Building 95. The only volatile compound detected in the sediment sample collected at SS-2 was TCE at 1.2J µg/kg. Semivolatile compounds detected in SS-2 include benzo(a)anthracene at 700J µg/kg, benzo(a)pyrene at 550J µg/kg, benzo(b)fluoranthene at 850 µg/kg, benzo(ghi)perylene at 380J µg/kg, benzo(k)fluoranthene at 260J µg/kg, chrysene at 710J µg/kg, fluoranthene at 1,500 µg/kg, indeno(1,2,3-cd)pyrene at 430J µg/kg, phenanthrene at 600J µg/kg, and pyrene at 1,300 µg/kg. In addition, TPH (JP-4) was detected in SS-2 at 15J mg/kg.

In the duplicate sediment sample collected at SS-2, methylene chloride was detected at 2.6J µg/kg, TCE was detected at 1.1J µg/kg, and trichlorofluoromethane was detected at 9.1 µg/kg. Semivolatile compounds detected in the duplicate of SS-2 include benzo(a)anthracene at 320J µg/kg, benzo(a)pyrene at 250J µg/kg, benzo(b)fluoranthene at 350J µg/kg, chrysene at 320J µg/kg, fluoranthene at 910 µg/kg, phenanthrene at 700J µg/kg, and pyrene at 700J µg/kg. In addition, TPH (JP-4) was detected in the duplicate of SS-2 at 12 mg/kg.

In SS-3, TCE was detected at 4.2J µg/kg. Semivolatile compounds detected in SS-3 include benzo(a)anthracene at 680J µg/kg, benzo(a)pyrene at 640J µg/kg, benzo(b)fluoranthene at 960 µg/kg, benzo(ghi)perylene at 540J µg/kg, benzo(k)fluoranthene at 360J µg/kg, chrysene at 750J µg/kg, fluoranthene at 1,600 µg/kg, indeno(1,2,3-cd)pyrene at 610J µg/kg, phenanthrene at 960 µg/kg, and pyrene at 1,400 µg/kg. In addition, TPH (JP-4) was detected in SS-3 at 20J mg/kg.

Sample, collected near Building 99, was the farthest downstream of the sediment samples at Site SS-41 (see Figure 2.4). In SS-1, the only volatile compound detected was TCE at 1.2J µg/kg. Semivolatile compounds detected in SS-1 included benzo(a)anthracene at 310J µg/kg, benzo(a)pyrene at 330J µg/kg, benzo(b)fluoranthene at 500J µg/kg, benzo(ghi)perylene at 310J µg/kg, chrysene at 400J µg/kg, fluoranthene at 840J µg/kg, indeno(1,2,3-cd)pyrene at 350J µg/kg, phenanthrene at 360J µg/kg, and pyrene at 650J µg/kg. In addition, TPH (JP-4) was detected in SS-1 at 13 mg/kg.

APPENDIX C

RISK EVALUATION

4. RISK EVALUATION

4.1 INTRODUCTION

A risk evaluation was conducted for the Fuel Hydrant System (Site SS-41) located at Charleston Air Force Base, Charleston, SC. The purpose of this evaluation was to assess potential risks to human health and the environment resulting from exposure to on-site media.

The methodology used in this assessment include SCDHEC guidance for Risk-Based Corrective Action (RBCA) for Petroleum Releases (SCDHEC, 1995) for indicator chemicals associated with petroleum-related contamination and USEPA Region IV screening methodology (USEPA, 1995a) for those constituents not included in the RBCA guidance. The RBCA guidance focuses on the evaluation of potential risks to human health and the Region IV screening guidance focuses on the evaluation of potential risks to both human health and the environment.

4.2 RISK-BASED CORRECTIVE ACTION (RBCA) EVALUATION

The RBCA methodology describes a tiered evaluation that includes 3 distinct tiers, beginning with a conservative Tier 1 approach and progressing to a complex, site-specific Tier 3 approach. The steps involved in the RBCA assessment are presented in Figure 4.1.

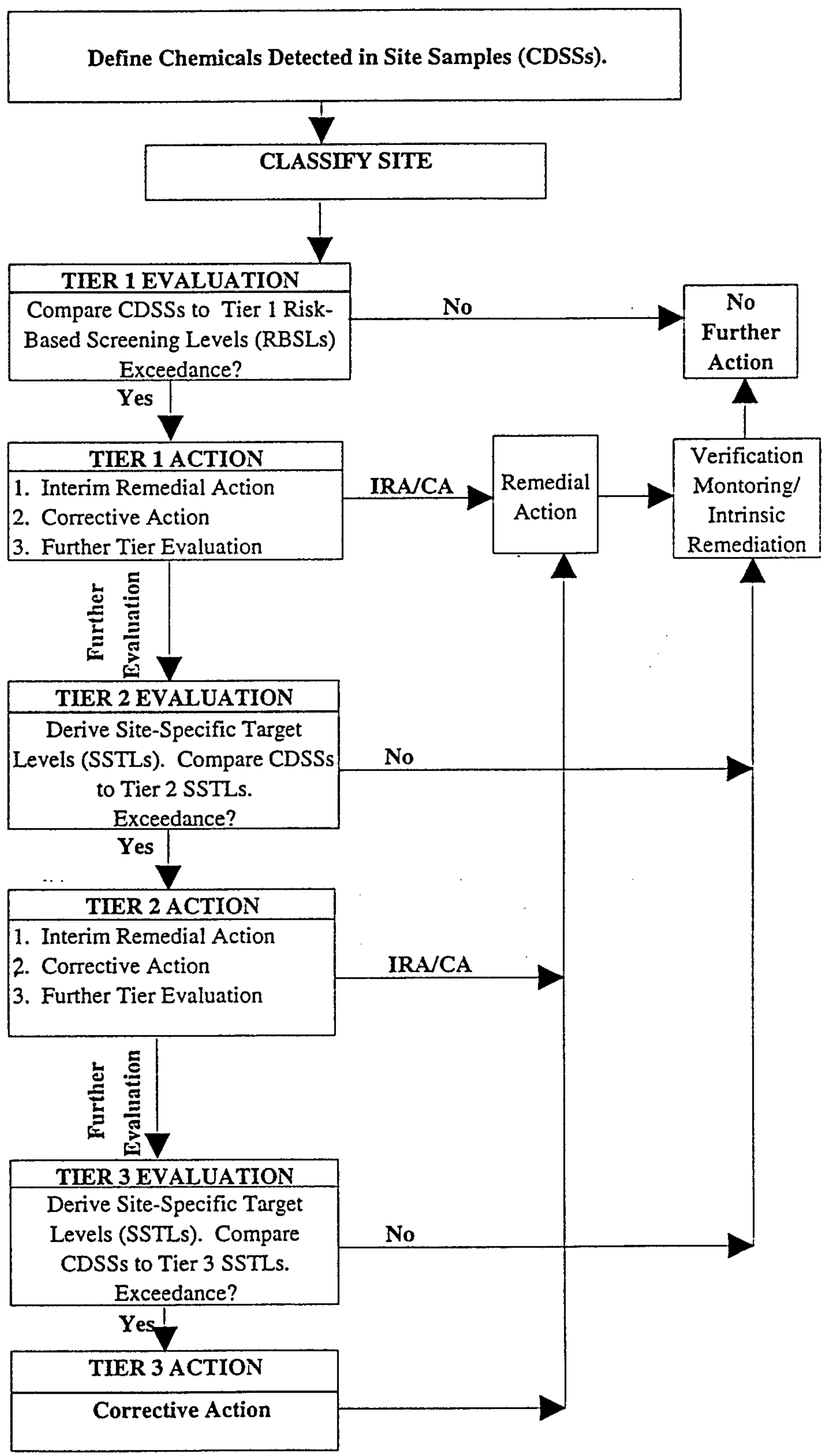
4.2.1 Initial Site Assessment

The primary source of contamination at the site is petroleum spills from the operation of the fuel hydrant system. The location of the maximum detected concentrations of contaminants in soil, groundwater, and surface water/sediment are discussed and presented in Section 3.0, Nature and Extent of Contamination. The maximum detected concentrations of contaminants in site media were located near the pumping stations. Section 3.0 discusses the chemicals present in site samples (CPSS) that were evaluated in the risk characterization.

A discussion of the site background, including the site description and site history, is presented in Section 1.0. Hydrogeological conditions at the site are discussed in Section 2.0. The overall direction of groundwater flow at the site is to the south. Shallow groundwater is expected to discharge to the flightline drainage ditch. Based on the groundwater flow velocity through the site, it is expected to take a minimum of 17 years for advective groundwater flow to reach the closest downgradient base boundary from Site SS-41 (distance of 4,800 ft).

The base obtains drinking water from the Charleston Commission of Public Works, with intakes located in major surface water bodies (Edisto River, Goose Creek Reservoir and Foster Creek). No domestic or industrial wells are known to be located in the surficial aquifer. The only known deep well in the vicinity of the site is maintained for limited private use and is located about three miles southwest of Charleston AFB. This well is 380 ft deep and supplies water for a heat pump and garden irrigation. Three deep

FIGURE 4-1
RISK-BASED CORRECTIVE ACTION EVALUATION
IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN



wells used to pump groundwater for industrial use are also located in the vicinity of the base.

Currently, the site is located within a patrolled military installation. Trespassing onto the site is not likely given that the site is surrounded by a fence and is patrolled by military personnel. Current receptors, therefore, include on-site military personnel. In the future, the site will remain a military facility. Consequently, the only realistic receptors will be future military workers.

The following potential receptors have been identified for Site SS-41:

4.2.1.1 Current and Hypothetical Future Off-Site Residents

Off-site residents are defined as those individuals that reside to the south of the site, over the Charleston AFB property boundary. These residents are currently supplied drinking water via the Charleston Commission of Public Works. Although highly unlikely, it is possible that future off-site residents will obtain their drinking water from a hypothetical private well located at the boundary of Charleston AFB. This well, however, would likely be located in the deep aquifer, which is not impacted by Site SS-41 contaminants, rather than the surficial aquifer. If a well were present in the surficial aquifer, however, contaminants resulting from Site SS-41 would not be present at significant concentrations, given the distance from the site to the installation boundary and the fact that it is estimated to take 17 years for site groundwater to reach the installation boundary under conditions of natural attenuation.

Given that the site is fenced and patrolled by the Air Force, and that the site is located on a flightline, it is highly unlikely that these nearby residents will trespass onto the site and become exposed to soil, surface water, and sediment. The only potential exposure of these receptors to site media is through the inhalation of volatiles and particulates from soil. Given the distance from the site to the residents, however, the concentration of contaminants that may reach the residents will be negligible. The off-site resident, therefore, is not expected to be impacted by contaminants in any on-site media now or in the future.

4.2.1.2 Current and Hypothetical Future Workers

Workers are defined as those individuals that are employed on-site and have unlimited access to media at the Fuel Hydrant System. Current and future workers will be exposed to surface soil as well as surface water and sediment located in the drainage ditch. In the future, workers will be exposed to surface soils comprised of a mixture of surface and subsurface soils, as a result of future excavation and redistribution of subsurface soils during future site development. Future workers are also assumed to obtain drinking water from on-site wells and, therefore, will be exposed to groundwater.

4.2.1.3 Hypothetical Future On-Site Residents

There are no current on-site residents. Given that the site is expected to remain a military installation in the future, and Site SS-41 is expected to remain in proximity to a flightline, future residential development of the site will not occur.

4.2.2 Site Priority Classification

The site is classified as a Class 5 priority, based on the current and projected degree of hazard to human health and the environment. A Class 5 designation indicates that there is no demonstrable threat to human health or the environment although CDSSs are expected to exceed Tier 1 Risk-Based Screening Levels (RBSLs) and further assessment is needed. Although the concentrations of CDSSs are relatively low, it was conservatively assumed that RBSLs would be exceeded and further assessment would be necessary.

4.2.3 Tier 1 Evaluation

The Tier 1 evaluation compares on-site concentrations to RBSLs provided in the RBCA guidance for indicator chemicals associated with petroleum contamination. Although TPH is included as an indicator chemical in the RBCA guidance, it cannot be quantitatively evaluated due to the lack of toxicity data. The RBSLs are based on conservative exposure scenarios.

The results of the Tier 1 evaluation are presented in Appendix C. For subsurface soils and sediment, separate evaluations were completed to assess direct contact with contaminants in these media and the potential impacts of contaminants leaching from soil to groundwater. For direct contact, RBSLs were available for both residential and industrial. Per RBCA guidance, the comparison was completed using the more conservative, residential value, although the industrial value is more applicable to site conditions.

For groundwater, the maximum detected concentration of benzene (86 ug/L) exceeded the RBSL (5 ug/L). No other VOC nor SVOC exceeded the RBSL.

For direct contact with subsurface soil (ingestion or dermal contact), the maximum detected concentration of benzo(b)fluoranthene (1.4 mg/kg) exceeded the RBSL (0.88 mg/kg for residential exposure). For the assessment of soil leaching to groundwater, the maximum concentrations of benzo(a)anthracene (0.79 mg/kg), benzo(b)fluoranthrene (1.4 mg/kg), and chrysene (1 mg/kg) exceeded RBSLs. Given that fewer than three detections were reported for any of these contaminants, the recommended screening against the mean of the top three detections was not possible and the RBSL was compared to the maximum detected concentration.

Sediments were evaluated as surface soils, which is a conservative assumption given that sediments are expected to be covered by surface water and will not be as readily available for exposure as soils. For direct contact (ingestion or dermal contact), the maximum detected concentration of benzo(b)fluoranthene (1.04 mg/kg) exceeded the RBSL (0.88 mg/kg). For the assessment of soil leaching to groundwater, the maximum detected concentrations of benzo(b)fluoranthene (1.04 mg/kg) and chrysene (0.84 mg/kg) exceeded RBSLs.

4.2.4 Tier 1 Action

The results of the Tier 1 evaluation reported that benzene in groundwater and several PAHs in subsurface soil and sediment exceeded RBSLs, indicating that No Further Action is not a reasonable Tier 1 Action. Given that few exceedances were reported, and that the

exceedances were within an order of magnitude of the RBSL, neither an Interim Remedial Action nor a Corrective Action Plan are appropriate at Site SS-41.

At the Site SS-41 site, further tier evaluation is the most appropriate. Given that the reasonably anticipated future use of the site is military, the residential scenarios used to establish the RBSLs are not appropriate. Further Tier 2 evaluation using an industrial exposure scenario will be used to allow for a more realistic assessment of contaminants at Site SS-41.

4.2.5 Tier 2 Evaluation

Given that the RBSLs used in the Tier 1 assessment were based on a residential exposure scenario, they are not applicable to the Fuel Hydrant System. The Tier 2 assessment focused on the derivation of SSTLs that reflect the current and future industrial use of the site. Additional data needed to complete the soil to groundwater leachability modeling in Tier 2 included on-site TPH, background total organic content and the distance from the highest detected concentration to groundwater.

SSTLs were derived for the ingestion of groundwater by workers. For soils, SSTLs were derived to address potential direct contact to soils as well as potential leachability of contaminants from soil to groundwater. Appendix C presents the results of the Tier 2 analysis for groundwater and soil.

4.2.5.1 Groundwater

SSTLs for groundwater were established to assess the ingestion of groundwater by hypothetical future workers. Although it is highly unlikely that future workers will obtain their drinking water from wells located in the surficial aquifer, SSTLs were established for these receptors. The SSTLs were based on the ingestion of 1L/day of water for 250 days/year over a period of 25 years by workers.

Benzene (maximum concentration of 86 ug/L), which exceeded the Tier 1 screening, also exceeded the Tier 2 screening. No other petroleum-related contaminants exceeded the Tier 1 or Tier 2 screening. Although benzene did exceed the Tier 2 screening, the likelihood of any worker being exposed to the groundwater in the future is extremely unlikely.

The assumed point of compliance for the groundwater is on-site. It is assumed that a future worker will be exposed to groundwater in the surficial aquifer. This is an extremely conservative assumption, however, given that the site is anticipated to continue to obtain its water via a municipal supply and that, if drinking water wells were to be placed on-site, they would be placed in the deep aquifer and not the surficial aquifer.

4.2.5.2 Soil

SSTLs for direct contact with soil/sediment were obtained from the Region IX Preliminary Remediation Goal (PRG) guidance (USEPA, 1995b). Per SCDHEC (1995) guidance, Tier 2 SSTLs should include potential exposure via ingestion, inhalation and dermal contact. The published Region IX PRGs include these pathways in the derivation

of PRGs for industrial receptors. There were no exceedances of Tier 2 for soil or sediment.

SSTLs for soil to groundwater leachability were derived using SCDHEC guidance (1995). The derivation of these SSTLs is presented in Appendix C. There were no exceedances of Tier 2 SSTLs for either subsurface soil or sediment.

4.2.6 Tier 2 Action

The results of the Tier 2 evaluation reported that benzene in groundwater exceeded the SSTL, indicating that Verification Monitoring/Intrinsic Remediation is not a reasonable Tier 2 Action for groundwater. For subsurface soil and sediment, however, no contaminants exceeded the Tier 2 SSTL, indicating that no adverse effects on human health are expected in receptors exposed to these media. Further evaluation of these media are not warranted. Given that only one (benzene in groundwater) exceedance was reported, and that the exceedance was within an order of magnitude, neither an Interim Remedial Action nor a Corrective Action Plan are appropriate at Site SS-41.

At Site SS-41, no further analysis of subsurface soil and sediment is recommended given that maximum concentrations of contaminants in these media did not exceed Tier 2 SSTLs.

For groundwater, given the exceedance of benzene, further tier evaluation is the most appropriate action. The assumed point of compliance for the groundwater is on-site. It is assumed that a future worker will be exposed to groundwater in the surficial aquifer. This is an extremely conservative assumption, however, given that the site is anticipated to continue to obtain its water via a municipal supply and that, if drinking water wells were to be placed on-site, they would be placed in the deep aquifer and not the surficial aquifer. The more realistic point of compliance for groundwater is the property boundary where it is possible that future off-site residents may be exposed to groundwater via a private well, although a private well is more likely to be located in the deep aquifer instead of the surficial aquifer. A Tier 3 analysis will evaluate this point of compliance using groundwater modeling results discussed in Section 5.

4.2.7 Tier 3 Evaluation

For groundwater, given the exceedance of benzene, Tier 3 analysis is appropriate. Using the groundwater modeling results discussed in Section 5, an evaluation of concentrations of benzene present at the point of compliance (property boundary) was performed. In Tier 2, the assumed point of compliance was on-site. This assumption is highly conservative given that the site is anticipated to continue to obtain its water via a municipal supply and that, if drinking water wells were to be placed on-site, they would be placed in the deep aquifer and not the surficial aquifer. The more realistic point of compliance for groundwater is the property boundary where it is possible that future off-site residents may be exposed to groundwater via a private well.

The Tier 3 analysis for benzene is presented in Appendix C. The analysis compares the results of the groundwater modeling at the property boundary to the Tier 1 RBSL, which evaluates potential residential exposure because it is more likely that a resident would be

exposed at the property boundary than a worker. The Tier 1 RBSL, therefore, becomes the Tier 3 SSTL for benzene. The concentration of benzene at the installation boundary does not exceed the SSTL for any of the pumping stations.

4.2.8 Tier 3 Action

Given that the modeled concentration of benzene in groundwater did not exceed the Tier 3 SSTL, verification monitoring/intrinsic remediation is recommended for groundwater.

4.3 REGION IV SCREENING

For those contaminants detected in Site SS-41 media, but not covered by the RBCA program, a site-specific screening was performed using Region IV screening methodology (USEPA, 1995a). The screening includes endpoints for the protection of both human health and the environment. The steps involved in the Region IV screening process are presented in Figure 4.2 and the results are presented in Appendix C.

4.4 SUMMARY AND CONCLUSIONS

4.4.1 Summary

A risk evaluation was conducted for the Fuel Hydrant System (Site SS-41) located at Charleston Air Force Base, Charleston, SC. The purpose of this evaluation was to assess potential risks to human health and the environment resulting from exposure to on-site media.

The methodology used in this assessment include SCDHEC guidance for Risk-Based Corrective Action (RBCA) for Petroleum Releases (SCDHEC, 1995) for indicator chemicals associated with petroleum-related contamination and USEPA Region IV screening methodology (USEPA, 1995a) for those constituents not included in the RBCA guidance. The RBCA guidance focuses on the evaluation of potential risks to human health and the Region IV screening guidance focuses on the evaluation of potential risks to both human health and the environment.

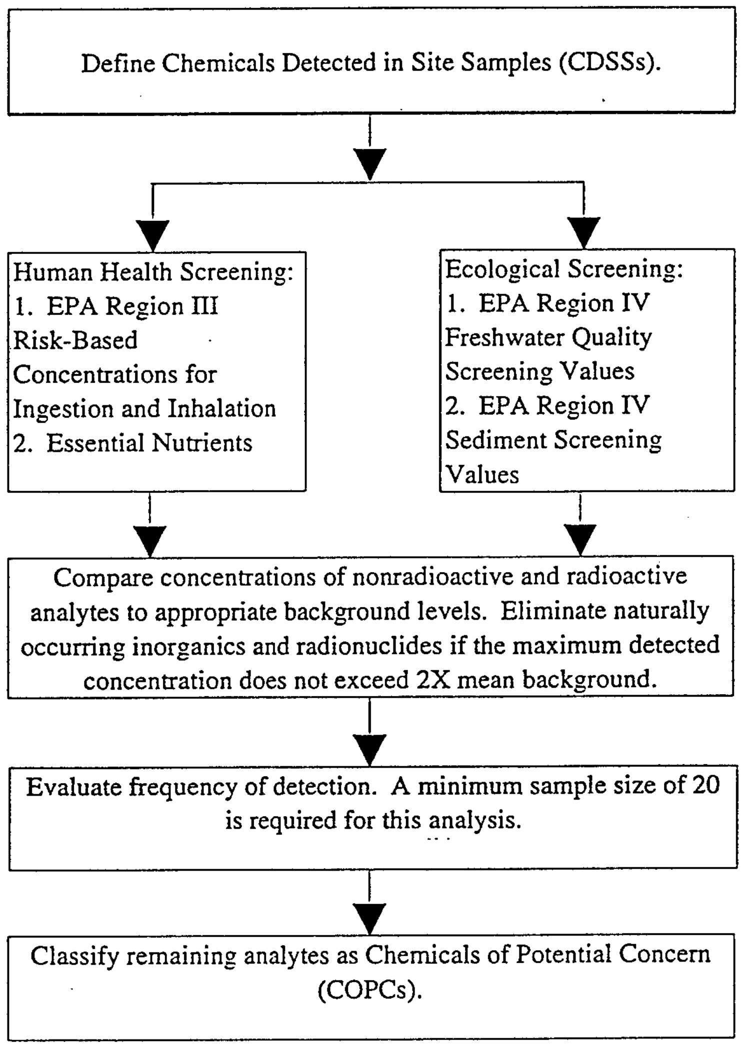
The results of the RBCA and Region IV screening process are discussed by media in the following sections.

4.4.1.1 Groundwater

Groundwater was assessed for potential impacts to human health only, ecological receptors at the site are not expected to be impacted by surficial groundwater. Because surficial groundwater is expected to discharge to surface water located in the flightline drainage ditch, the surface water and sediment in the drainage ditch were evaluated for ecological impacts.

A Tier 3 RBCA screening was completed for groundwater at Site SS-41. No contaminants were identified following the screening process, resulting in a recommended RBCA action of short-term monitoring to verify intrinsic remediation.

FIGURE 4-2
HUMAN/ECOLOGICAL DATA EVALUATION
IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN
EPA REGION IV METHODOLOGY



For those contaminants not included in the RBCA process, several metals were present that exceeded both RBCs and a background screen. The elevated concentrations of these metals in groundwater, however, may have resulted from sampling techniques that allowed inclusion of sediments with the groundwater sample. One organic contaminant (p-isopropyltoluene) was not evaluated because an RBC was not available. Given that organic is not a known contaminant at Site SS-41 and that the frequency of detection was very low (1/14), non-inclusion of this contaminant in the evaluation should not result in should not significantly effect the results.

4.4.1.2 Subsurface Soil

Subsurface soil was assessed for potential exposure of future on-site industrial workers. Future industrial development of the site is expected to result in excavation and redistribution of subsurface soils onto the site, resulting in potential exposure of future receptors to subsurface soils. Subsurface soils were not addressed for ecological receptors.

A Tier 2 RBCA screening was completed for subsurface soils. The screening included an evaluation of potential direct contact (ingestion or dermal contact) as well as potential leachability of contaminants from soil to groundwater. Neither scenario resulted in an exceedance of Tier 2 screening criteria.

For those chemicals not included in the RBCA process, benzo(a)pyrene and arsenic exceeded both the industrial RBC and/or background. Benzo(a)pyrene, however, was detected in only one out of twelve samples and the RBCA evaluation determined that the indicator PAHs did not result in adverse effects on humans. Therefore, the exceedance of benzo(a)pyrene in the Region IV screening process (maximum detected of 0.85 mg/kg vs. Industrial SSTL of 0.78 mg/kg) is not considered to be significant. Arsenic is not a known contaminant at the site and the source of the elevated arsenic concentration in subsurface soils is not known.

Two organic contaminants (p-isopropyltoluene and n-propylbenzene) were not evaluated because RBCs were not available. Given that these organics are not known contaminants at Site SS-41 and that the frequency of detection was very low (1-2/14), non-inclusion of these contaminants in the evaluation should not result in should not significantly effect the results. Additionally, RBCs were not available to evaluate benzo(ghi)perylene and phenanthrene. The RBCA process, however, evaluated indicator PAHs which did not exceed SSTLs. Consequently, it is assumed that because the indicator PAHs did not exceed SSTLs, the site should be acceptable for all PAHs.

4.4.1.3 Surface Water

Surface water was not addressed using the RBCA guidance, but was addressed using the Region IV screening process. Surface water was addressed for potential impacts to both human health and the environment.

For human health, exceedances were found for several PAHs, bis (2-ethylhexyl) phthalate, iron and manganese. The screening criteria evaluated, however, reflected ingestion of surface water as well as organisms, such as fish. Given that the surface water is located in a drainage ditch on the side of a flightline, exposure of humans to surface

water and organisms within the ditch is highly unlikely. The screening criteria recommended by Region IV was completed, but is not appropriate for the surface water use at Site SS-41.

Region IV ecological screening values were available for only nine chemicals detected in surface water at Site SS-41. Maximum detected concentrations of bis (2-ethylhexyl) phthalate, aluminum, copper, and iron exceeded chronic screening values. Copper and bis (2-ethylhexyl) phthalate, however, were detected in only one sample. Several additional chemicals were also retained as COPCs due to the lack of screening values. However, many of these chemicals were also detected in only one sample with the exception of the metals and TPH. Due to the low frequency of detection of many of the COPCs and the low habitat values of the Site SS-41 area, the exposure of ecological receptors to COPCs in surface water resulting in significant effects is unlikely.

4.4.1.4 Sediment

Sediment was addressed for potential impacts to both human health and the environment. For human health, sediment was addressed in both the RBCA and Region IV screening processes as surface soil. This is a conservative assumption given that the sediment in the ditch is expected to be covered with surface water, rendering it unavailable for ingestion by future workers.

A Tier 2 RBCA screening was completed for sediment. The screening included an evaluation of potential direct contact (ingestion or dermal contact) as well as potential leachability of contaminants from soil to groundwater. Neither scenario resulted in an exceedance of Tier 2 screening criteria.

For those chemicals not included in the RBCA process, arsenic exceeded both the industrial RBC and background. Arsenic is not a known contaminant at the site and the source of the elevated arsenic concentration in subsurface soils is not known. Although RBCs were not available to evaluate benzo(ghi)perylene and phenanthrene, the RBCA process evaluated indicator PAHs. It is assumed that because the indicator PAHs did not exceed SSTLs, the site should be acceptable for all PAHs.

Region IV ecological screening values were available for only twelve chemicals detected in sediments at Site SS-41. Maximum detected concentrations of several PAHs and arsenic exceed screening values. Arsenic, however, was detected in only one sample. Inorganic chemical concentrations were also compared to two times the mean surface soil background concentration. Several additional chemicals (VOCs, PAHs, TPH, and metals) were retained as COPCs due to the lack of Region IV screening values or because they exceeded background. All VOCs were detected in only one sample with the exception of trichloroethene. The exposure of ecological receptors to COPCs in sediment resulting in significant effects, however, is unlikely due to the low habitat values of the Site SS-41 area.

5. EVALUATION OF CORRECTIVE ACTION ALTERNATIVES

Four general corrective action alternatives are available per the SCDHEC RBCA guidance as follows: intrinsic remediation with verification monitoring, interim remedial action, further tier evaluation, and corrective action (which includes some element of active cleanup). In general, the soil and groundwater contamination detected at Site SS-41 which is related to site activities is minor. The only monitoring wells that indicated concentrations of contaminants addressed by RBCA above Tier I RBSLs were MW-3 and MW-11. In both wells, benzene exceeded the RBSL during the first round of groundwater sampling, but was below the RBSL during the second round of sampling. No subsurface soil contaminants addressed by RBCA exceeded Tier I criteria. Some compounds not addressed by RBCA exceeded the Region IV risk screening levels in soil, groundwater, sediment, and surface water. However, due to the environmental setting at Site SS-41, no exposures of potential receptors or completed exposure pathways are expected.

While there are no known sources for metals concentrations that were detected in media at the site, concentrations of many metals exceeded EPA Region IV risk screening levels in soil, sediment, and groundwater. The concentrations of metals in groundwater samples are believed to result from sediment in highly turbid groundwater samples. Confirmatory sampling of groundwater using alternative purging and sampling methods to assure collection of clear, sediment-free groundwater samples should be performed prior to taking action to address metals concentrations in groundwater.

5.1 DISCUSSION OF CORRECTIVE ACTION OPTIONS

5.1.1 Interim Remedial Action

No free-phase product has been observed at the site. There are no fire or explosion hazards related to the site contamination and no immediate threats to human health or the environment are present. Normal base operations and policies control access to the area surrounding Site SS-41 precluding direct contact with contaminated media. Interim remedial actions are not appropriate for Site SS-41.

5.1.2 Corrective Action Using Active Remediation

A pilot bioventing project was performed by Parsons ES in the area of Building 93 from approximately July 1994 through July 1995. The project was successful in reducing the concentrations of fuel hydrocarbons in soil in the pilot test area by one to three orders of magnitude. AFCEE plans to expand the pilot bioventing system in this area to a full-scale system. As a part of the planned bioventing system expansion at Building 93, a focused sampling event will be performed to fine-tune the delineation of soil hydrocarbon contamination to optimize placement of the full-scale system.

Several petroleum hydrocarbon compounds were retained as COCs in subsurface soil in the risk evaluation. Four compounds; p-isopropyltoluene, n-propylbenzene, benzo(ghi)perylene, and phenanthrene did not have EPA Region IV screening criteria

against which to compare. In addition, benzo(a)pyrene exceeded the residential and industrial RBCs. All of the preceding compounds were detected in soil samples collected in the vicinity of Building 93 only. The full-scale bioventing system should remediate these compounds in soil at the site.

The only petroleum hydrocarbon compound that was retained as a COC in groundwater after RBCA Tier II evaluation was benzene in MW-11 (at a maximum of 86 µg/L). In addition, bis (2-ethylhexyl) phthalate exceeded the RBC during the second round of groundwater sampling in MW-11 at 6J µg/L. Bis (2-ethylhexyl) phthalate is not a constituent of petroleum fuels and its presence in trace concentrations may be a site or laboratory artifact. The bioventing system expansion should provide further source reduction of petroleum hydrocarbons in soil in the vicinity of Building 93. As a result, petroleum hydrocarbon compounds which may be present as a source of leaching from soil to groundwater should be controlled by this planned bioventing system.

5.1.3 Further Tier Evaluation

The only contaminant that exceeded RBCA Tier II evaluation criteria for groundwater was benzene. The exceedance in MW-11 will be addressed indirectly using active source reduction in soild at Building 93 (the AFCEE bioventing project). The RBCA Tier I exceedance in MW-3 will be addressed by intrinsic remediation (see Section 5.1.4 below). As further assurance that benzene at the concentrations detected in MW-3 during the Parsons ES investigation will not reach an off-base receptor, the groundwater transport modeling discussed in Section 5.1.4.4 can be applied.

5.1.4 Intrinsic Remediation with Verification Monitoring

Intrinsic remediation is a risk management strategy that relies on natural attenuation to control exposure to contaminants in the subsurface. Mechanisms of natural attenuation of contaminants in groundwater include physical, chemical, and biological processes which cause spatial and temporal reduction of contaminant concentrations. Most physical and chemical attenuation processes are nondestructive; in other words, the concentrations of contaminants are reduced but the original mass of contaminant is still present in the environment. Nondestructive physical and chemical attenuation processes include dilution and mechanical dispersion, solubility, sorption, and volatility. In destructive attenuation processes, the contaminant is chemically changed or permanently removed from the environment. Biodegradation is the main destructive attenuation process which occurs in the groundwater environment. Biodegradation of fuel hydrocarbons will occur when an indigenous population of hydrocarbon-degrading microorganisms is present in the soil and groundwater, and sufficient concentrations of electron acceptors and nutrients, including fuel hydrocarbons, are available to these organisms. Soils and groundwater with a history of exposure to fuel hydrocarbon compounds generally contain microbial populations capable of facilitating biodegradation reactions (Zobell, 1946; Litchfield and Clark, 1973; Borden, 1994).

5.1.4.1 Evidence of Contaminant Biodegradation Over Time and Distance

The first step in determining whether site data indicate that COCs are biodegrading in soils and groundwater at Site SS-41 was to compare analytical data on the nature and extent of site contamination collected during previous investigations. The purpose of this comparison was to assess the evidence of field-scale contaminant mass loss. Changes in the nature and extent of contamination at a site over time that cannot be explained by physical processes (e.g., leaching from soils, transport in groundwater) may be an indication that contaminants are biodegrading at the site.

Building 93 was the only area in which soils were sampled in previous investigations and during the recent Parsons ES investigation. Comparison of BTEX concentrations detected in soil samples at Building 93 (see Tables 3.2 and 3.3) suggest that concentrations of petroleum fuel compounds in soil have decreased over time. Soil samples collected during the Parsons ES investigation (SB-3 through SB-9; see Figure 2.3 for locations) contained few detections of BTEX compounds (see Table 3.2). Pre-test and post-test soil sampling assoicated with the one-year bioventing pilot study showed up to three orders of magnitude BTEX reduction due to aerobic biodegradation. The totential influence of the bioventing system on soil samples collected during this investigation is unknown around Building 93.

At Building 99, six groundwater monitoring wells have been sampled periodically since 1990. The only monitoring well at Building 99 which has consistently contained fuel hydrocarbon concentrations is MW-3. Table 5.1 summarizes the petroleum hydrocarbon concentrations detected in MW-3 through time. The benzene, toluene, ethylbenzene, xylene, and naphthalene concentrations have all decreased dramatically over the five year period on record. The only additional monitoring well in which petroleum hydrocarbon contaminants were detected at significant concentrations at Site SS-41 was in MW-11 (Building 93). The BTEX compound concentrations varied significantly over the two sampling rounds performed by Parsons ES (see Tables 3.3 and 3.4). For example, benzene was detected at 86 µg/L on 10/18/95 and was detected at 2J µg/L on 11/14/95.

The first line of evidence for natural attenuation of petroleum hydrocarbon contaminants at Site SS-41 is the decreasing concentrations of compounds measured at the same locations over time. While soil samples may not be from precisely the same locations, the petroleum hydrocarbon concentrations in general were much lower during the recent Parsons ES investigation compared with the earlier investigations. Comparison of concentrations in MW-3 over time strongly suggest that dissolved petroleum hydrocarbon concentrations are being attenuated at the site.

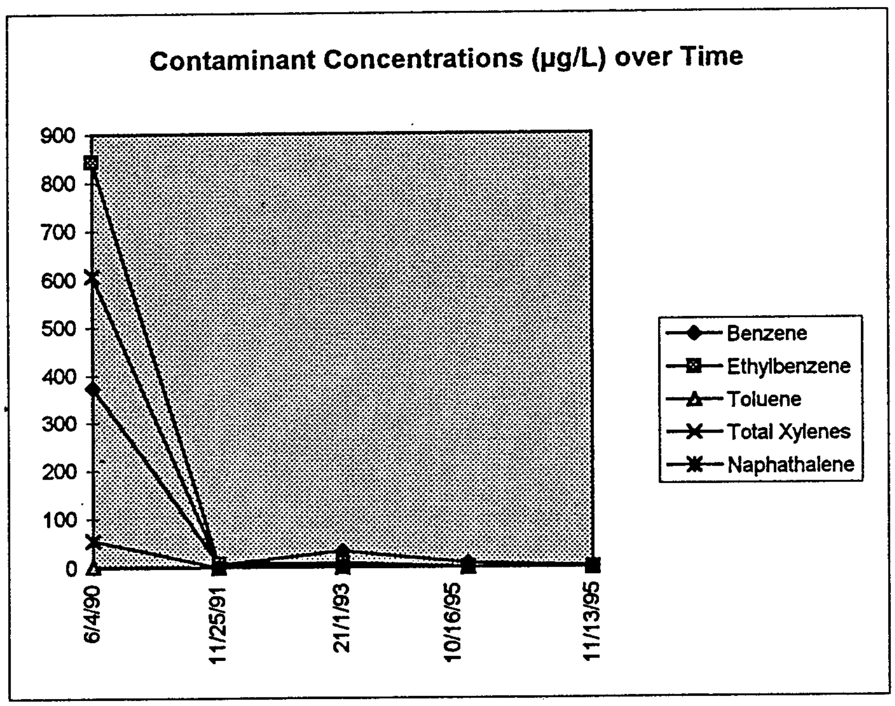
5.1.4.2 Evidence of Contaminant Biodegradation via Microbially Catalyzed Redox Reactions

A second line of evidence for natural attenuation of petroleum hydrocarbon contaminants in groundwater is the use of geochemical indicators (potential electron acceptors) of biodegradation (Salanitro, 1993; McCallister and Chaing, 1994; Wiedemeier *et al.*, 1995; Borden *et al.*, 1995). Reductions in the concentrations of oxidized chemical species that are used by microorganisms to facilitate the oxidation of BTEX compounds within contaminated media is another indication that contaminants are biodegrading. The

TABLE 5.1
MW-3 PETROLEUM COMPOUND CONCENTRATIONS OVER TIME
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

COMPOUND (µg/L)	6/4/90	11/25/91	21/1/93	10/16/95	11/13/95
Benzene	374	6.1	33.2	9.3	3
Ethylbenzene	843	7.8	10.4	0.77 J	0.92 J
Toluene	3	ND	2.75	1 U	1 U
Total Xylenes	607	3.6	< 7.5	0.63 J	1 U
Naphathalene	55	ND	6.96	1.2	1 U

Notes: ND = Not detected.
J = Estimated value.
U = Not detected.



amount of potential electron acceptors available to participate in contaminant biodegradation reactions can be used to estimate the total contaminant mass that can be biodegraded over time at this site.

Microorganisms obtain energy to replenish enzymatic systems and to reproduce by oxidizing organic matter. Biodegradation of the BTEX compounds is the result of a series of redox reactions that maintain the charge balance within the natural environment. Microorganisms facilitate the degradation of the BTEX compounds by transferring electrons from the contaminant (electron donor) to available electron acceptors. Electron acceptors are elements or compounds that occur in relatively oxidized states and can participate in redox reactions involving the BTEX compounds. Electron acceptors known to be present in groundwater at Site SS-41 are oxygen, ferric iron, sulfate, and carbon dioxide. A summary of geochemical indicator parameters is shown in Table 5.2. The most significant electron acceptors as suggested by the analysis of indicator parameters are dissolved oxygen (DO), carbon dioxide (indicated by methane), and to a lesser extent, ferric iron (indicated by ferrous iron). Figures 5.1, 5.2, and 5.3 show the three locations at Site SS-41 (Buildings 99, 95, and 93) at which wells are located along with total BTEX concentrations and concentrations of the most significant indicator parameters at each location.

Almost all types of fuel hydrocarbons can be biodegraded under aerobic conditions (Borden, 1994). Mineralization of fuel hydrocarbons to carbon dioxide and water under aerobic conditions involves the use of oxygen as a cosubstrate during the initial stages of metabolism, and as a terminal electron acceptor during the later stages of metabolism for energy production (Higgins and Gilbert, 1978; Gibson and Subramanian, 1984; Young, 1984). The reduction of molecular oxygen during the oxidation of the BTEX compounds yields a significant amount of free energy to the system that the microorganisms could utilize.

On the basis of free energy yield and the oxidizing potential of the site groundwater, the carbon dioxide-methane (CO_2-CH_4) redox couple also could be used to oxidize fuel hydrocarbon compounds to carbon dioxide and water once the groundwater is sufficiently reducing. To attain these reducing levels, other highly oxidizing chemical species such as oxygen, nitrate, and sulfate must be reduced. This redox reaction is called methanogenesis or methane fermentation. The presence of methane in groundwater at elevated concentrations relative to background concentrations is a good indicator of methane fermentation.

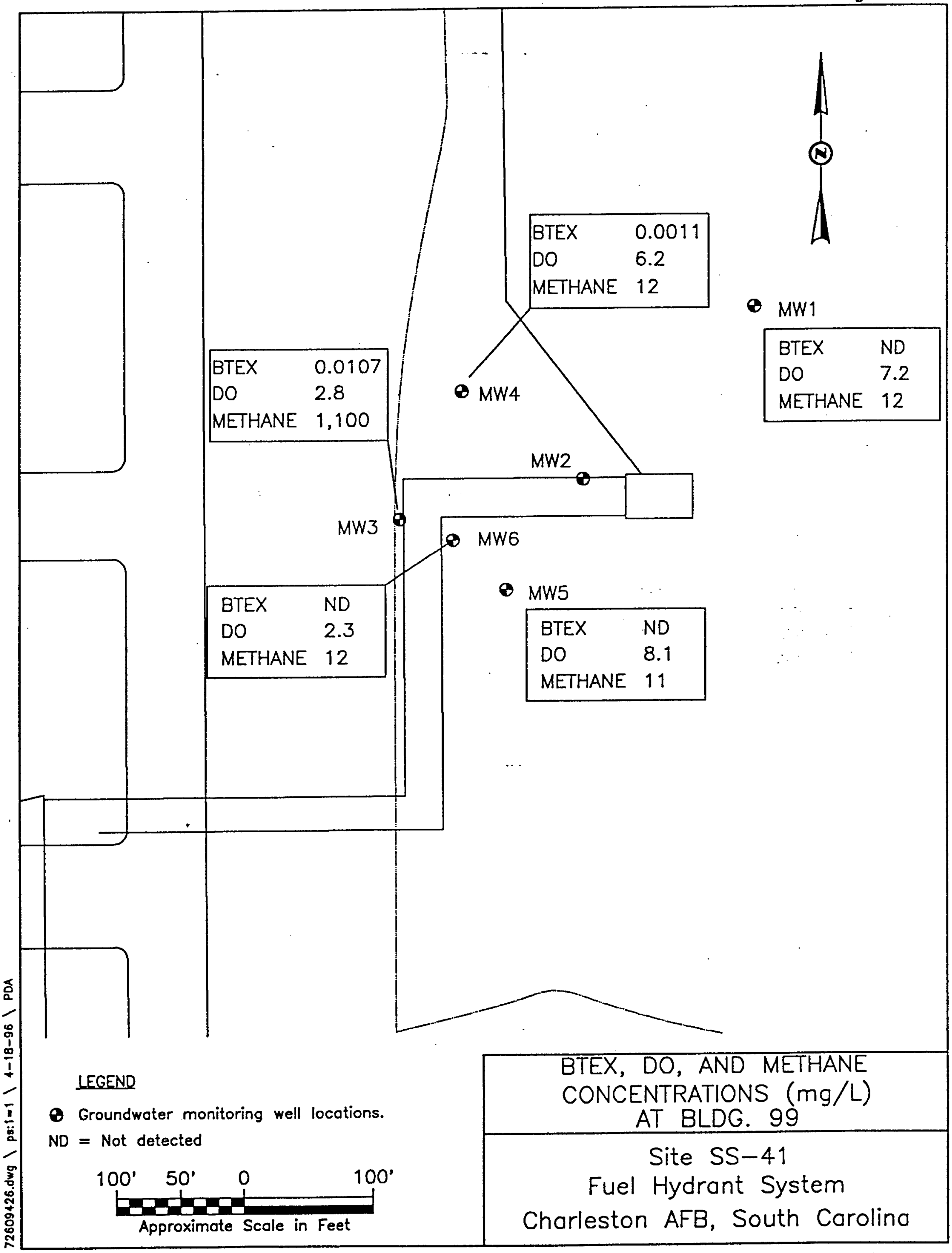
Although relatively little is known about the anaerobic metabolic pathways involving the reduction of ferric iron (Fe^{3+}), this process has been shown to be a major metabolic pathway for some microorganisms (Lovely and Phillips, 1988; Chapelle, 1993). Elevated concentrations of ferrous iron (Fe^{2+}) often are found in anaerobic, fuel-contaminated groundwater systems. Concentrations of dissolved ferrous iron once were attributed to the spontaneous and reversible reduction of ferric oxyhydroxides, which are thermodynamically unstable in the presence of organic compounds such as benzene. However, recent evidence suggests that the reduction of ferric iron cannot proceed at all without microbial mediation (Lovely and Phillips, 1988; Lovely *et al.*, 1991; Chapelle, 1993).

TABLE 5.2
INORGANIC GEOCHEMICAL PARAMETERS
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

Well No.	Ferrous[1] Iron (mg/L)	Nitrate[2] (mg/L)	Sulfate[1] (mg/L)	pH[2]	Conductivity[2] (μmhos/cm)	Temperature[2] (°C)	Methane[1] (mg/L)	Dissolved Oxygen[2] (mg/L)
MW-1	22 J	-0.7	14	5.79	110	23.7	12	7.2
MW-3	3.3 J	0	5	5.74	275	18.2	1,100	2.8
MW-4	0.16 J	-0.2	3	6.16	210	23.7	12	6.2
MW-5	0.24 J	0.1	8	6.01	117	23.7	11	8.1
MW-6	0.041 U	0.5	5	10.5	300	23.7	12	2.3
MW-7	120 J	-0.7	15	6.23	124	23	12	4.7
MW-8	18 J	0.5	14	6.07	150	23	120	2.4
MW-9	27 J	0.4	9	5.82	69	24.1	12	5.2
MW-10	90 J	-0.7	39	5.79	440	21	5.6 U	2.4
MW-11	330 J	-0.7	13	4.86	110	19	430	4.6
MW-12	23 J	0.9	9	4.49	92	21	31	2
MW-13	6.2 J	0	7	5.9	128	19	500	4
MW-14	3.3 J	0.6	11	5.22	90	21	20	5

Notes:
[1] = Laboratory analysis result.
[2] = Field analysis result.
J = Estimated value.
Negative values interpreted as not detected.
U = Not detected.
Water samples analyzed 16-Oct-95 through 18-Oct-95.

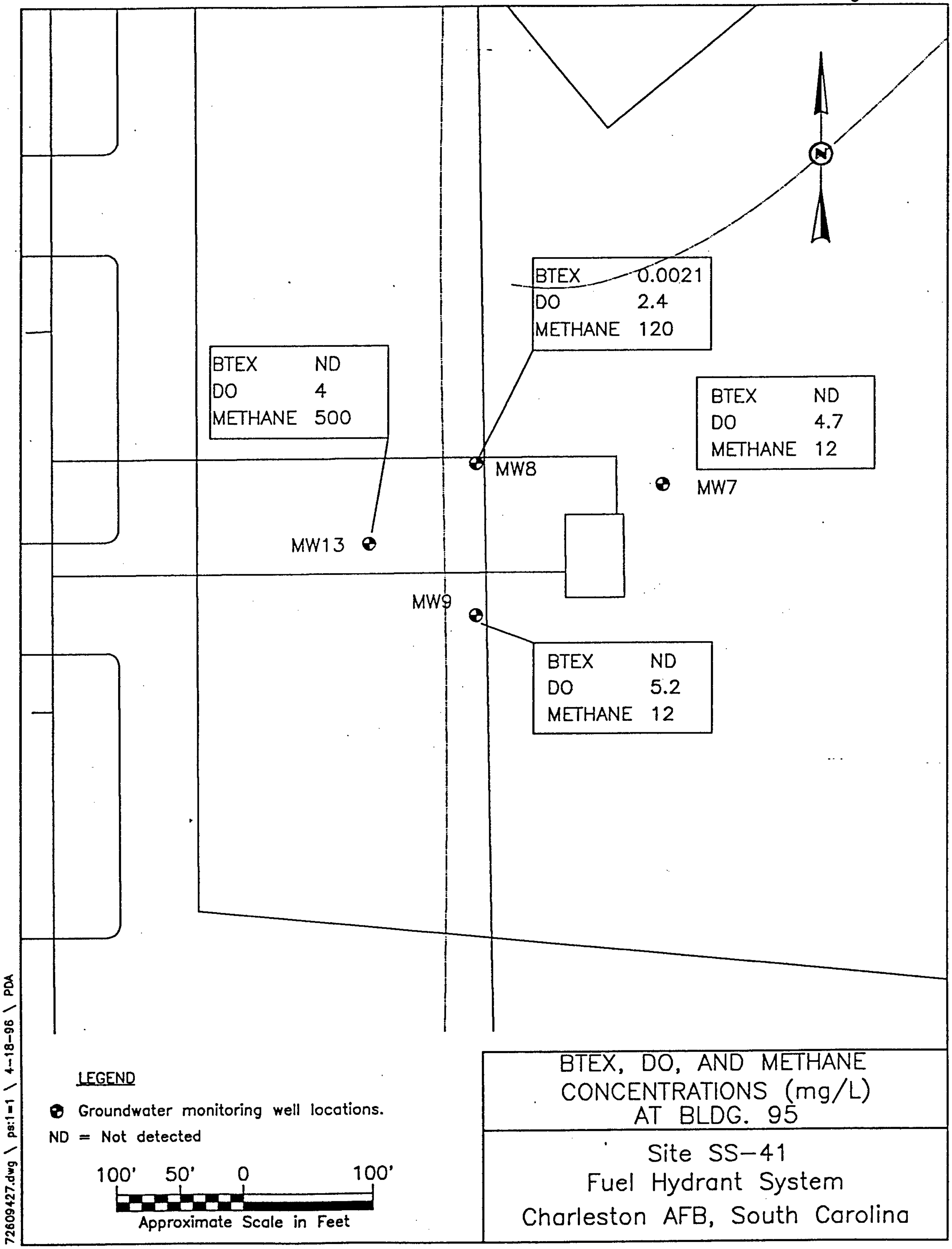
Figure 5.1



BTEX, DO, AND METHANE CONCENTRATIONS (mg/L) AT BLDG. 99

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

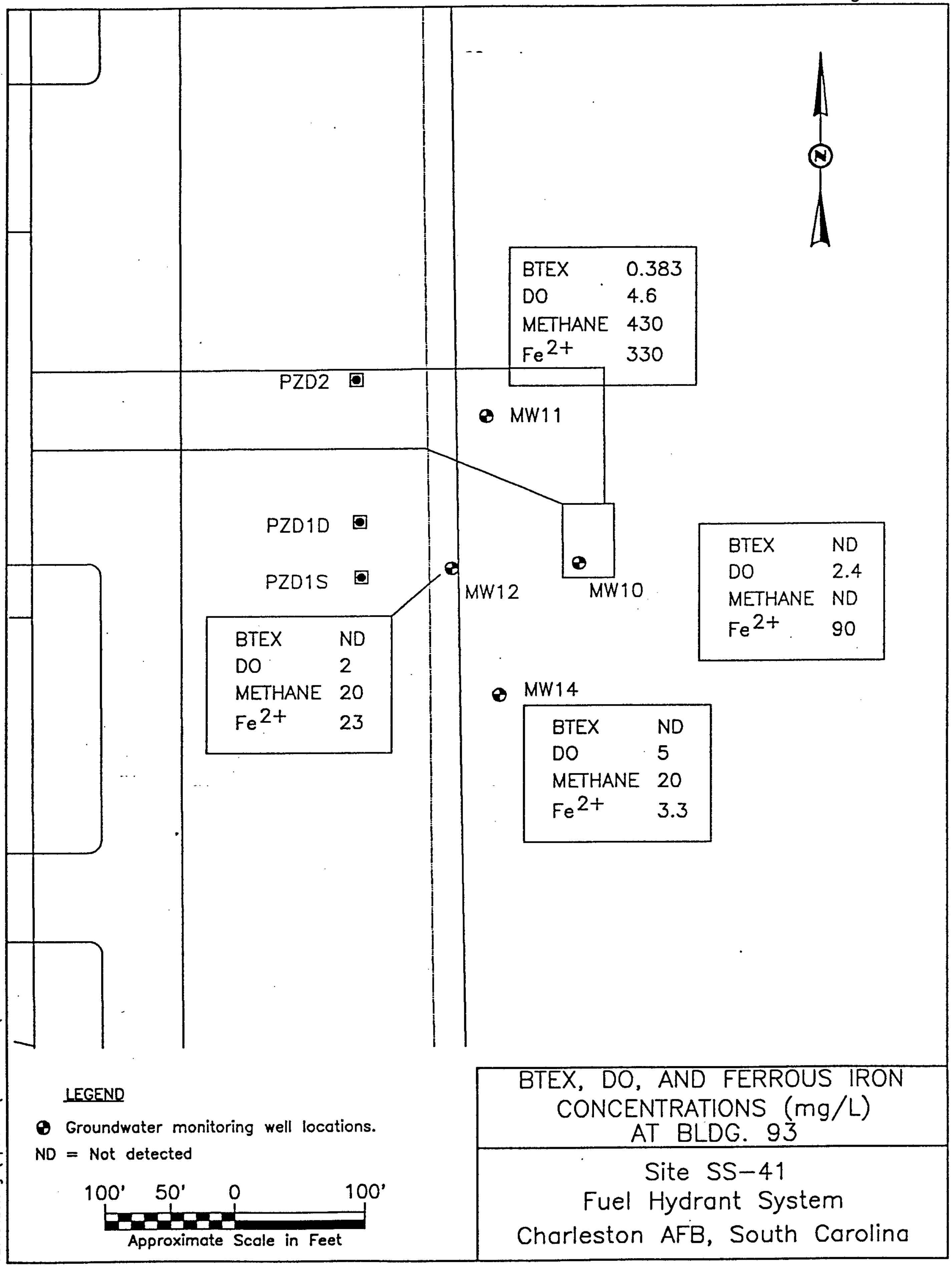
Figure 5.2



BTEX, DO, AND METHANE CONCENTRATIONS (mg/L) AT BLDG. 95

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

PARSONS ENGINEERING SCIENCE, INC.



BTEX, DO, AND FERROUS IRON CONCENTRATIONS (mg/L) AT BLDG. 93

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

PARSONS ENGINEERING SCIENCE, INC.

At Building 99 (see Figure 5.1), higher BTEX concentrations correlated well with decreased DO concentrations and increased methane concentrations. Groundwater not affected by petroleum hydrocarbon contamination (MW-1, MW-5) contained DO concentrations in the range of 7 to 8 mg/L. One exception is MW-6 which is completed into a deeper aquifer. Elevated methane and depleted DO concentrations in MW-3 suggests that microbially mediated degradation of petroleum hydrocarbon compounds is occurring in groundwater at Building 99.

At Building 95 (see Figure 5.2), increased BTEX concentrations correlated well with decreased DO concentrations and increased methane concentrations. Unaffected groundwater DO ranged from 4 to 5 mg/L. MW-13 contained anomalously high methane (500 mg/L) which may be the result of activities along the aircraft maintenance apron. In MW-8, total BTEX was 2.1 µg/L, DO was reduced to 2.4 mg/L and methane was elevated to 120 mg/L. Elevated methane and depleted DO concentrations in MW-8 suggest that microbially mediated degradation of petroleum hydrocarbon compounds is occurring at Building 95.

At Building 93 (see Figure 5.3), increased BTEX concentrations correlated well with increased methane and ferrous iron concentrations. In MW-11, where BTEX in groundwater was detected at 383 µg/L, the methane concentration was 430 mg/L and the ferrous iron concentration was 330 mg/L. DO concentrations did not correlate as well at Building 93. Elevated methane and ferrous iron concentrations coupled with BTEX in MW-11 suggest that microbially mediated degradation of petroleum hydrocarbon compounds is occurring at Building 93.

5.1.4.3 Theoretical Assimilative Capacity Estimate

To assess the full potential for long-term intrinsic remediation of petroleum hydrocarbons at Site SS-41, an estimate of the contaminant mass that can be biodegraded at the site was made. Mass balance relationships can be used to determine how much contaminant mass can be degraded by each of the redox reactions that the microorganisms might use to make free energy available for cell maintenance and production. The stoichiometric relationships between the contaminants and the electron acceptors have been developed to estimate the mass of BTEX which can be degraded per unit mass of electron acceptor utilized (Wiedemeier *et al.*, 1995). Estimates of the background concentrations of the most significant electron acceptors detected at Site SS-41 that appear to be operating at the site to biodegrade fuel hydrocarbon compounds are listed in Table 5.3 along with the calculated assimilative capacities for each. On the basis of these calculations, the groundwater at Site SS-41 has the capacity to degrade a total BTEX concentration of 1,296,060 µg/L. The maximum BTEX concentration detected at Site SS-41 was 383 µg/L in MW-11. It is important to note that the expressed assimilative capacity estimate derived in Table 5.3 is an upper-bound estimate because it assumes complete mixing of BTEX and available electron acceptors, instantaneous reaction rates, and complete mineralization. Actually, the total reservoir of electron acceptors will not be available to the microorganisms because of mass transfer, kinetic, and other biological and chemical limitations.

TABLE 5.3
ESTIMATE OF EXPRESSED ASSIMILATIVE CAPACITY OF GROUNDWATER
FUEL HYDRANT SYSTEM (SITE SS-41)
CHARLESTON AFB, SOUTH CAROLINA

Electron Acceptor	Background Concentration (μg/L)	Mass of BTEX Degraded per unit mass of Electron Acceptor Utilized (mg)[1]	Mass of BTEX Degraded per unit mass of Metabolic Byproduct Produced (mg)[1]	Initial BTEX Assimilative Capacity[2] (μg/L)
Oxygen	8,000	0.32		2,560
Ferric Iron[3]	300,000		0.045	13,500
Methane[3]	1,000,000		1.28	1,280,000
			Total	1,296,060
			Maximum Detected	383

[1] = Simple average of all BTEX compounds based on individual compound stoichiometry.

[2] = Calculated based on the ratio of the total mass of electron acceptor required to oxidize a given mass of total BTEX.

[3] = This represents the reduced form of the electron acceptor. Assimilative capacity is expressed only as an estimate. Does not represent the actual total reservoir of electon acceptor to be exhausted.

5.1.4.4 Nondestructive Attenuation

As previously introduced, nondestructive attenuation involves a reduction in contaminant concentrations, but retention of the original mass of contaminant in the environment. To evaluate nondestructive attenuation of contaminants in groundwater at

Site SS-41, a conservative analytical groundwater transport model was performed. The model calculates one-dimensional solute transport and includes advective and dispersive transport (Bear, 1979). Retardation on aquifer media is included in the model, but was set to unity (i.e., no retardation was applied to the calculations). Advective transport is based on the hydraulic gradient through Site SS-41 toward the base boundary to the south-southeast. Dispersion is the tendency of solute to spread out as it flows through the aquifer due to mechanical mixing and diffusion. The calculations performed by the model are shown in detail in Appendix D.

Three generic scenarios were used for transport modeling. In each scenario, the transport distance and the coefficient of longitudinal dispersivity for that distance are used as variables. The three distances used were 8,000 ft, 6,000 ft, and 4,800 ft, which correspond to the distances from Buildings 93, 95, and 99, respectively to the downgradient base boundary. The coefficients of longitudinal dispersivity were estimated based on the nomograph presented in Electric Power Research Institute (1985) for field scale dispersivity. In each transport scenario, an initial solute concentration of 1 gram per liter (gm/L) was used as the peak concentration of an assumed 100-foot long contaminant plume centered on wells MW-11, MW-7, and MW-3 at Buildings 93, 95, and 99, respectively. The model calculates the arrival curve of the contaminant at the base boundary along with the associated peak concentration and time required for the peak to reach the receptor (the base boundary). The peak concentrations calculated for each model scenario can be used as contaminant reduction factors for estimation of the peak concentrations of any of the COCs originating from any of the three Buildings at Site SS-41. The contaminant reduction factors for solute originating at Buildings 93, 95, and 99 are 0.0048, 0.0064, and 0.0078, respectively. For example; for the peak detected concentration of bis (2-ethylhexyl) phthalate at Building 95, the 16 µg/L at MW-7 would result in a peak concentration of 0.1024 µg/L (16 x 0.0064) in 19.7 years (the peak arrival time calculated by the model) at the base boundary.

The calculated contaminant reduction factors for solute reaching the base boundary from Site SS-41 were calculated using conservative assumptions. No dilution from rainfall-recharge to groundwater was included in the model. Advective-dispersive transport was calculated using a one-dimensional model, therefore reductions in solute concentrations due to lateral spreading (transverse dispersivity) were not included in the model. If contaminated groundwater originating at Site SS-41 discharges to the flightline drainage ditch prior to exiting the base boundary through groundwater transport, the concentrations of contaminants would be reduced through volatilization, dilution with other uncontaminated groundwater discharge along the ditch, and dilution with storm water inflows. Surface water and sediment contaminants detected during the Parsons ES investigation are discussed in detail in Sections 3 and 4. In general, contaminants detected

in sediment and surface water in the flightline drainage ditch do not correspond directly to contaminants in soil and groundwater at Site SS-41.

The peak arrival times at the base boundary for contaminants originating in groundwater at Buildings 99, 95, and 93 are 15.7 years, 19.7 years, and 26.2 years, respectively. These time frames allow for verification monitoring of groundwater and surface water downgradient from Site SS-41. Verification monitoring is an integral part of the intrinsic remediation alternative for corrective action. Groundwater monitoring points should be established several years upgradient of the base boundary along the groundwater flow pathway from Site SS-41 to allow time to respond to unexpected migration of contaminants in unacceptable concentrations.

5.2 STATEMENT OF RECOMMENDATION AND RATIONALE FOR SELECTION

Implementation of intrinsic remediation with verification monitoring at Site SS-41 is recommended as the primary alternative for corrective action at the site. This recommendation is based on the delineation of petroleum hydrocarbon contamination at the site, the controls on the source area(s), and the estimated assimilative capacity of the groundwater environment. Intrinsic remediation should provide ample contaminant reduction both through destructive attenuation (biodegradation) and nondestructive attenuation (groundwater contaminant dispersion). Verification monitoring should be performed under the protocol presented in Section 6 to provide an "early warning system" for potential contaminant migration in groundwater to exit the site, as well as to verify that intrinsic remediation is reducing contaminant levels in groundwater.

Institutional controls on site access and continued land use for base operations (industrial use) should be maintained to eliminate the potential for future human exposure to contaminants. It is recommended that access to the site continue to be restricted to prevent unplanned ground disturbance in the source area(s). Excavation work in the source area(s) should only be performed by workers who have been briefed on the nature of onsite contamination and are trained in proper use of personal protective equipment. Because Site SS-41 consists of an open area bordered by an aircraft maintenance apron, taxiways, and runways, access is restricted as matter of Air Force security. These operations are not foreseen as subject to change, so institutional controls to restrict site access is not an issue.

The proposed AFCEE bioventing project in the area of former Building 93 should provide source removal necessary to reduce the concentrations of the few petroleum hydrocarbon compounds which were detected in this vicinity to acceptable levels. No further actions are recommended for the areas surrounding Buildings 95 and 99. No known sources for metals contaminants exist at Site SS-41. The concentrations of metals in groundwater are believed to be a result of solids in the samplesand most likely represent either naturally-occurring or anthropogenic background levels. Confirmatory sampling of groundwater using alternative purging and sampling methods should be used in the future to assure collection of clear, sediment-free groundwater samples. Confirmatory sampling should be performed prior to taking action to address metals concentrations in groundwater.

6. VERIFICATION MONITORING PLAN

6.1 GROUNDWATER MONITORING NETWORK

A total of 11 wells will be used to monitor contaminant removal and migration throughout Site SS-41 over time. These wells are located within, upgradient from, and downgradient from the dissolved petroleum hydrocarbon plume(s) to ensure that natural attenuation processes are occurring at rates sufficient to remove contaminant mass and minimize downgradient transport in groundwater. The locations of the wells to be used for verification monitoring are shown in Figure 6.1.

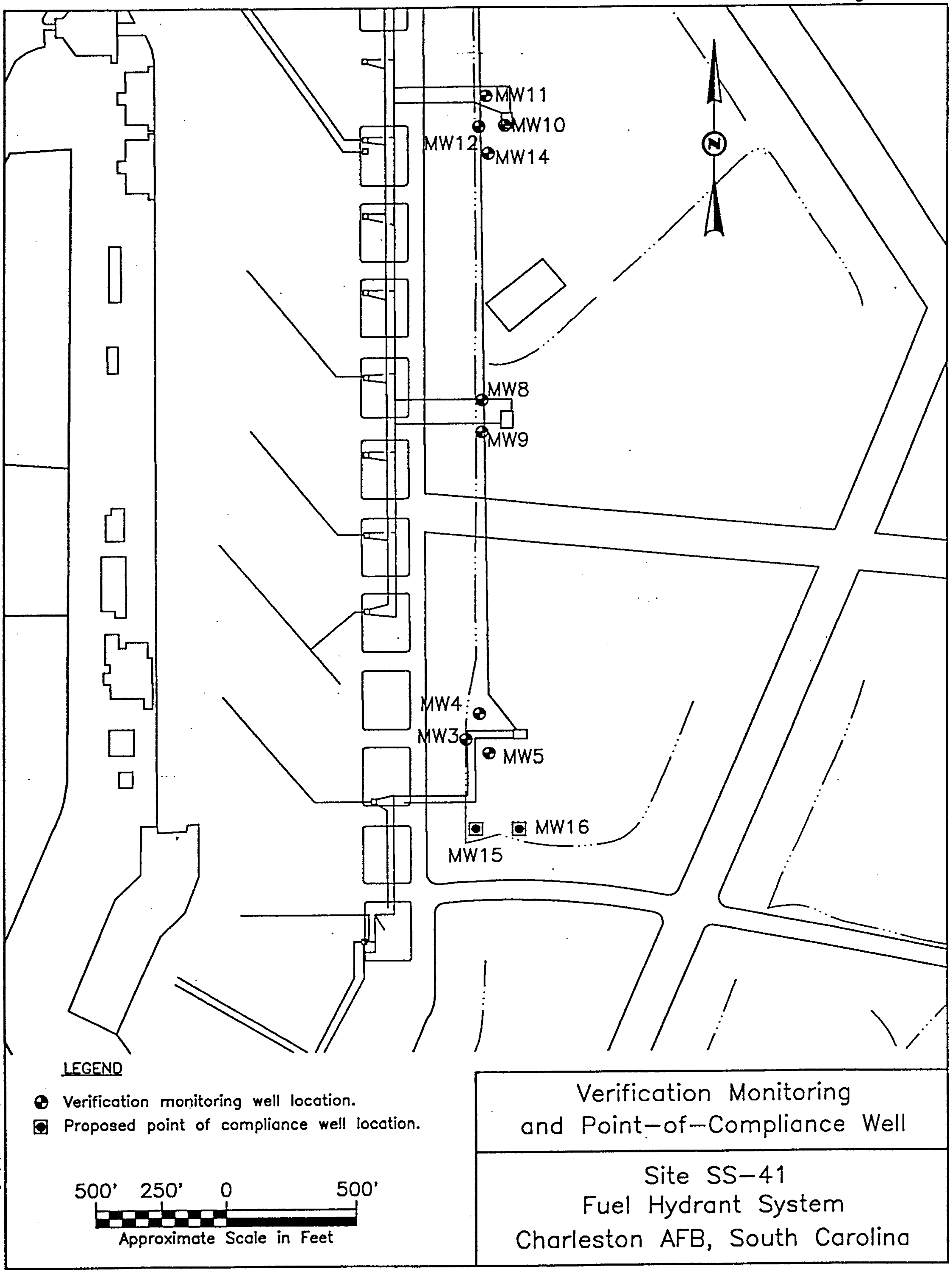
At Building 93, all four wells installed during the recent Parsons ES investigation will be used for groundwater monitoring. MW-11 contained the highest levels of petroleum hydrocarbon compounds at Site SS-41. The other three wells in this vicinity (MW-10, MW-12, and MW-14) will be sampled to detect local-scale migration of petroleum hydrocarbon compounds. At Building 95, MW-8 and MW-9 will be used for verification monitoring. MW-8 was the only well at this building that contained petroleum hydrocarbon compounds during the Parsons ES investigation and MW-9 is regionally downgradient. At Building 99, three monitoring wells (MW-3, MW-4, and MW-5) will be used for verification monitoring. MW-3 has historically contained petroleum hydrocarbon compounds, and tracking the reduction of compounds in this well has proved useful in demonstrating that intrinsic remediation is occurring at Site SS-41. MW-4 is upgradient from MW-3 and also contained low concentrations of petroleum hydrocarbons during the recent Parsons ES investigation. MW-5 is regionally the most downgradient well currently located at Site SS-41.

Two additional wells will be installed downgradient of Site SS-41 immediately north of taxiway #6 and east of the flightline drainage ditch as point-of-compliance (POC) wells for contaminant migration. MW-15 and MW-16 (see Figure 6.1) will be located approximately 2 years groundwater migration distance downgradient from Building 99. Placement of POC wells to the south of taxiway #6 is not recommended due to possible interferences with potential contamination originating from Area of Concern P. Wells MW-15 and MW-16 will be constructed similarly to the wells installed during the recent Parsons ES investigation. In general, the wells will be 2-inch diameter PVC including a 10 foot section of 0.010-inch slot screened interval installed to a total depth of approximately 15 feet bls. Exact dimensions of well construction details are subject to change pending evaluation of field conditions.

The POC wells will be monitored to ensure that no petroleum hydrocarbon compounds at concentrations exceeding the SCDHEC RBCA Tier I RBSLs will migrate beyond the immediate controlled area around Site SS-41. The detection of compounds exceeding the RBCA Tier I RBSLs will trigger the need to evaluate contingency actions. Contingency actions could include, but should not be limited to the following:

- resampling the POC wells to confirm concentrations in excess of the RBSLs;
- reevaluation of POC well locations (there will still be greater than 10 years groundwater travel distance before reaching the base boundary; and

Figure 6.1



Verification Monitoring and Point-of-Compliance Well

Site SS-41
Fuel Hydrant System
Charleston AFB, South Carolina

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- additional engineering evaluations to determine if more aggressive remedial efforts, such as groundwater extraction or sparging, are necessary and/or feasible.

6.2 GROUNDWATER SAMPLING

It is recommended that the monitoring wells at Site SS-41 be sampled once for confirmatory data regarding metals concentrations. The wells will be purged and sampled using a peristaltic pump set to a low flow rate (less than 100 milliliters per minute) to ensure that sediments are not entrained in the groundwater samples. The groundwater samples should be analyzed for the same list of metals analyzed during the recent Parsons ES investigation. Results should be compared to the data developed during the Parsons ES investigation, the EPA risk screening levels, and background concentrations. This evaluation of metals in groundwater at Site SS-41 should be performed prior to planning any further action or monitoring of metals at the site.

The verification monitoring wells and the POC wells described above will be sampled on a semiannual basis. Groundwater samples will be collected using the low flow peristaltic pumping method described above. During purging, groundwater will be analyzed in the field for temperature, pH, conductivity, DO, and redox potential. Samples will be send to a SCDHEC-approved laboratory for analysis by EPA Method 8020 for aromatic hydrocarbons.

Verification monitoring will be performed for a minimum of two years. After two years, the trend in contaminant concentrations will be evaluated along with any further data developed by the AFCEE bioventing project. If contaminant concentrations have fallen below the SCDHEC RBCA RBSLs for two consecutive sampling events after the initial two years of monitoring (or over the last two monitoring events during the initial two year program), Charleston AFB should request that SCDHEC issue a "no further action" letter, and the monitoring program may be eliminated.

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APPENDIX A

WELL CONSTRUCTION RECORDS

NCWELL 01/30/1996 15:55:58

SOIL BORING LOG AND WELL CONSTRUCTION RECORD

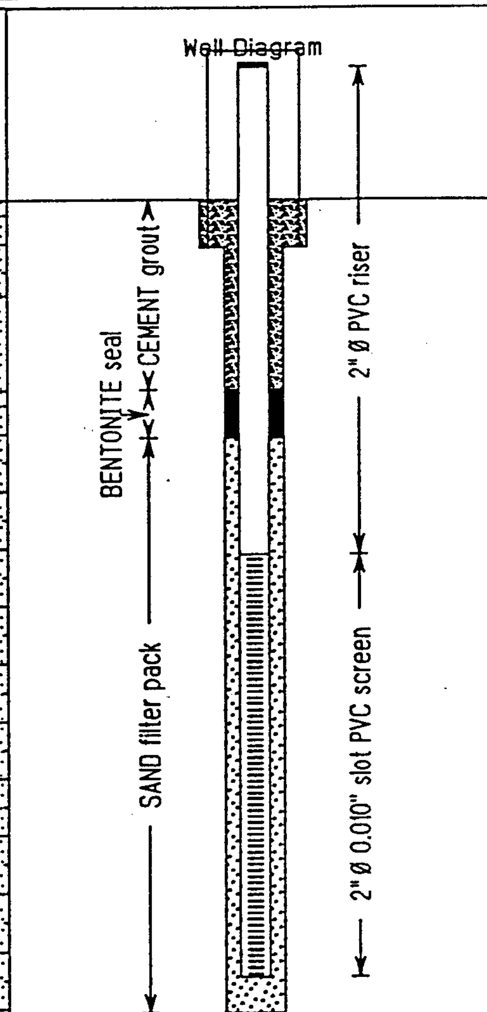
Client: AMC
Site: Fuel Hydrant System Charleston AFB
Project Identification Number: 726094-04000
Geol./Eng. Supervising Soil Boring: W.L. Schmithorst
Drilling Method (s): HSA
Sampling Method (s): SS
Soil Boring Start Date: 10/02/95
Soil Boring Termination Date: 10/03/95
Drilling Company: Alliance
Borehole Diameter (inches): 8
Borehole Depth (feet below surface): 17
Surface Elevation (feet MSL): 38.51
Top of Casing Elevation (feet MSL): 41.24

Soil Boring Identification Number: MW-7
Well Identification Number: MW-7
Geol./Eng. Supervising Well Installation: W.L. Schmithorst
Casing Installation Date: 10/03/95
Seal Grouting Date: 10/03/95
Casing Material: 2" Ø PVC
Screen Material: 2" Ø 0.010" slot PVC
Casing Interval (feet below surface): -2.73 to 7.43
Screened Interval (feet below surface): 7.43 to 16.23
Total Well Depth (feet below surface): 16.23
Water Level Measurement Date: 10/16/95
Depth to Water (feet below top of casing): 9.91
Water Level Elevation (feet MSL): 31.33

Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class	Graphic Log
0.0–2.0	X	5,44, 19,20	70	0.0	SAND fine to medium (85%), silt (15%), grayish orange (10YR7/4).	SM	
2.0–4.0	X	6,9, 13,15	90	0.0	SAND fine to medium (100%), grayish brown (5YR3/2).	SM	
4.0–6.0	X	6,11, 13,10	90	0.0	SAND fine to medium (90%), silt (10%), moderate brown (5YR4/4).	SM	
6.0–8.0	X	6,9, 13,11	90	0.0	SAND fine (80%), silt (20%), light gray (N7).		
8.0–10.0	X	5,5, 11,13	50	na	SAND fine to medium (90%), silt (10%), light gray.		
10.0–12.0	X	4,2, 2,5	70	na	Same as above.		
12.0–14.0	X	5,4, 5,7	70	na	Same as above.		
14.0–16.0	X	2,3, 4,8	70	na	Same as above.		
16.0–24.0					*Soil boring was terminated at 17' below ground surface.*		

Well Diagram



PARSONS ENGINEERING SCIENCE

GTGS \ 726094 \ MW-07.LOG

NCWELL 01/30/1996 16:18:59

SOIL BORING LOG AND WELL CONSTRUCTION RECORD

Client AMC
Site Fuel Hydrant System Charleston AFB
Project Identification Number 726094-04000
Geol./Eng. Supervising Soil Boring W.L. Schmithorst
Drilling Method (s) HSA
Sampling Method (s) SS
Soil Boring Start Date 10/03/95
Soil Boring Termination Date 10/03/95
Drilling Company Alliance
Borehole Diameter (inches) 8
Borehole Depth (feet below surface) 17
Surface Elevation (feet MSL) 37.57
Top of Casing Elevation (feet MSL) 40.14

Soil Boring Identification Number SB-2
Well Identification Number MW-9
Geol./Eng. Supervising Well Installation W.L. Schmithorst
Casing Installation Date 10/03/95
Seal Grouting Date 10/03/95
Casing Material 2" Ø PVC
Screen Material 2" Ø 0.010" slot PVC
Casing Interval (feet below surface) -2.57 to 6.35
Screened Interval (feet below surface) 6.35 to 16.27
Total Well Depth (feet below surface) 16.27
Water Level Measurement Date 10/16/95
Depth to Water (feet below top of casing) 12.25
Water Level Elevation (feet MSL) 27.89

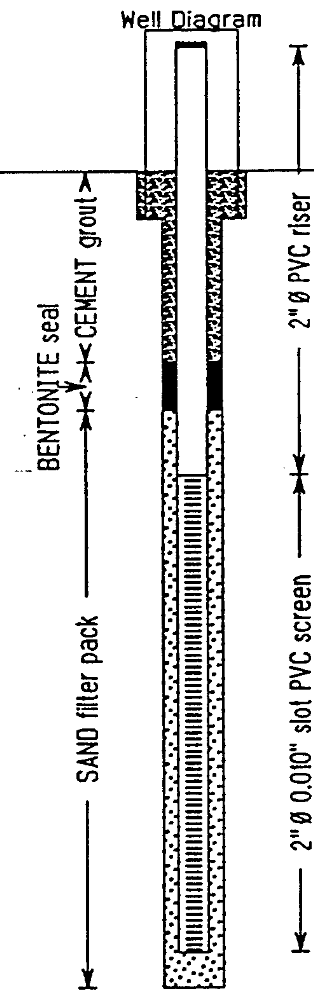
Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class
0.0–2.0	X	5,4, 5,5	100	0.0	SAND fine to medium (70%), silt (25%), clay (5%), moderate brown (5YR4/4).	SM
2.0–4.0	X	6,8, 8,8	100	0.0	SAND fine to medium (90%), clay (10%), light brown (5YR5/6).	SC
4.0–6.0	X	6,6, 7,8	80	0.0	SAND fine to medium (85%), clay (15%), light gray (N7).	
6.0–8.0	X	5,6, 8,10	80	0.0	Same as above.	
8.0–10.0	X	1,2, 2,3	70	na	SAND fine micaceous (100%), grayish orange pink (5YR7/2).	SM
10.0–12.0	X	1,1, 1,7	70	na	Same as above.	
17.0					*Soil boring was terminated at 17' below ground surface.*	

Depth scale: 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0

Graphic Log

Well Diagram



Water Level

PARSONS ENGINEERING SCIENCE

GTGS \ 726094 \ MW-09.LOG

NCWELL 01/30/1996 16:17:05

SOIL BORING LOG AND WELL CONSTRUCTION RECORD

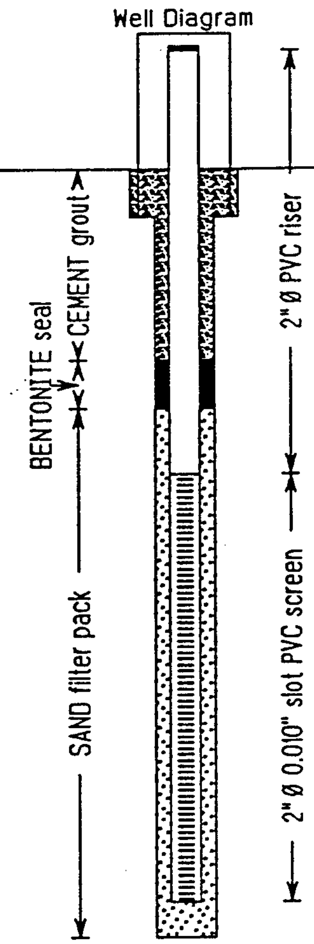
Client AMC
Site Fuel Hydrant System Charleston AFB
Project Identification Number 726094-04000
Geol./Eng. Supervising Soil Boring W.L. Schmithorst
Drilling Method (s) HSA
Sampling Method (s) SS
Soil Boring Start Date 10/03/95
Soil Boring Termination Date 10/03/95
Drilling Company Alliance
Borehole Diameter (inches) 8
Borehole Depth (feet below surface) 16
Surface Elevation (feet MSL) 37.43
Top of Casing Elevation (feet MSL) 39.90

Soil Boring Identification Number MW-10
Well Identification Number MW-10
Geol./Eng. Supervising Well Installation W.L. Schmithorst
Casing Installation Date 10/03/95
Seal Grouting Date 10/03/95
Casing Material 2" Ø PVC
Screen Material 2" Ø 0.010" slot PVC
Casing Interval (feet below surface) -2.47 to 6.35
Screened Interval (feet below surface) 6.35 to 15.27
Total Well Depth (feet below surface) 15.27
Water Level Measurement Date 10/16/95
Depth to Water (feet below top of casing) 11.04
Water Level Elevation (feet MSL) 28.86

Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class	Graphic Log	Water Level
0.0–2.0	X	4,4, 5,5	70	0.0	SAND fine to medium (80%), silt (15%), clay (5%), grayish brown (5YR3/2).	SM		
2.0–4.0	X	4,10, 11,11	80	0.0	SAND fine to medium (80%), silt (15%), clay (3%), organic material (2%), grayish brown (5YR3/2).			
4.0–6.0	X	4,3, 4,5	80	0.0	SAND fine to medium (80%), silt (15%), clay (3%), organic material (2%), dusky brown (5YR2/2).			
6.0–8.0	X	3,3, 3,4	100	0.0	Same as above.			
8.0–10.0	X	4,2, 6,8	70	0.0	SAND fine to medium micaceous (95%), clay (5%), medium light gray (N6).	SM		▽
10.0–12.0	X	4,4, 4,5	80	0.0	Same as above.			
12.0–14.0	X	3,4, 5,4	90	na	Same as above.			
14.0–16.0								
16.0					*Soil boring was terminated at 16' below ground surface.*			
18.0								
20.0								
22.0								
24.0								

Well Diagram



PARSONS ENGINEERING SCIENCE

GTGS \ 726094 \ MW-10.LOG

NCWELL 01/30/1996 16:17:13

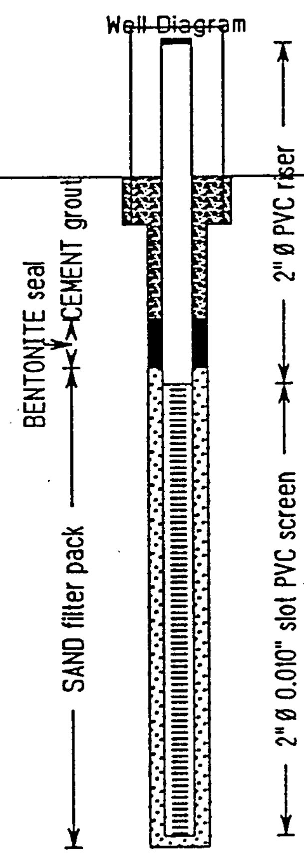
SOIL BORING LOG AND WELL CONSTRUCTION RECORD

Client: AMC
Site: Fuel Hydrant System Charleston AFB
Project Identification Number: 726094-04000
Geol./Eng. Supervising Soil Boring: W.L. Schmithorst
Drilling Method (s): HSA
Sampling Method (s): SS
Soil Boring Start Date: 10/03/95
Soil Boring Termination Date: 10/03/95
Drilling Company: Alliance
Borehole Diameter (inches): 8
Borehole Depth (feet below surface): 14
Surface Elevation (feet MSL): 34.81
Top of Casing Elevation (feet MSL): 37.56

Soil Boring Identification Number: SB-3
Well Identification Number: MW-11
Geol./Eng. Supervising Well Installation: W.L. Schmithorst
Casing Installation Date: 10/03/95
Seal Grouting Date: 10/03/95
Casing Material: 2" Ø PVC
Screen Material: 2" Ø 0.010" slot PVC
Casing Interval (feet below surface): -2.75 to 4.35
Screened Interval (feet below surface): 4.35 to 13.77
Total Well Depth (feet below surface): 13.77
Water Level Measurement Date: 10/16/95
Depth to Water (feet below top of casing): 9.55
Water Level Elevation (feet MSL): 28.01

Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class	Graphic Log	Well Diagram	Water Level
0.0	X	5,5, 8,9	80	0.0	SAND fine to medium (80%), silt (20%), grayish brown (5YR3/2).	SM			
2.0	X	5,6, 8,13	80	>2500	SAND fine to medium (80%), silt (20%), grayish orange pink (5YR7/2).				
4.0	X	12,15, 18,23	70	>2500	SAND fine to medium (85%), clay (15%), gray (N6).	SC			
6.0	X	4,4, 3,5	100	>2500	Same as above.				
8.0	X	4,3, 3,4	100	na	Same as above.				
10.0	X	4,3, 5,4	100	na	Same as above.				
12.0	X	2,2, 3,4	100	na	Same as above.				
14.0					*Soil boring was terminated at 14' below ground surface.*				
16.0									
18.0									
20.0									
22.0									
24.0									



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PARSONS ENGINEERING SCIENCE

NCWELL 01/30/1998 16:17:20

SOIL BORING LOG AND WELL CONSTRUCTION RECORD

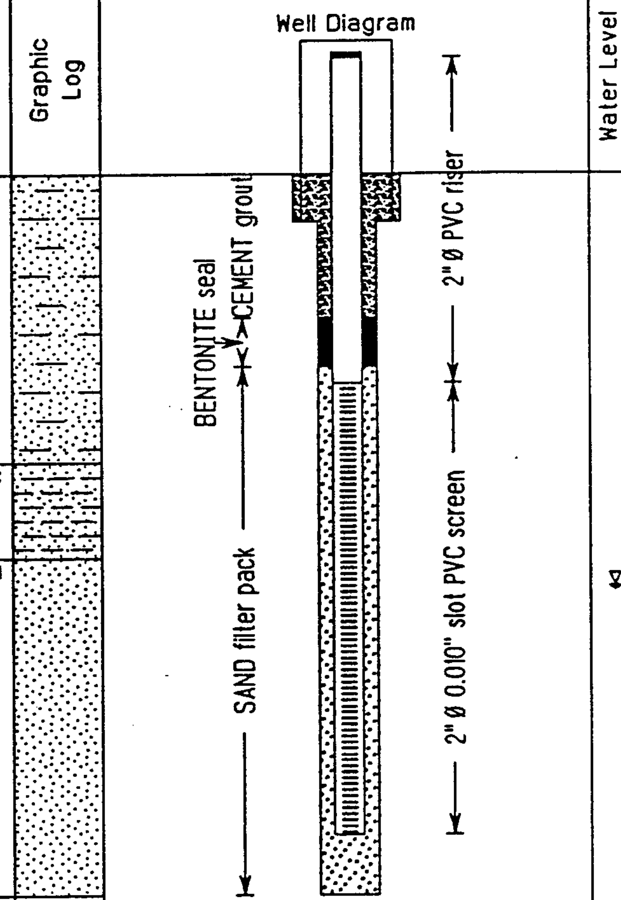
Client AMC
Site Fuel Hydrant System Charleston AFB
Project Identification Number 726094-04000
Geol./Eng. Supervising Soil Boring W.L. Schmithorst
Drilling Method (s) HSA
Sampling Method (s) SS
Soil Boring Start Date 10/04/95
Soil Boring Termination Date 10/04/95
Drilling Company Alliance
Borehole Diameter (inches) 8
Borehole Depth (feet below surface) 15
Surface Elevation (feet MSL) 36.14
Top of Casing Elevation (feet MSL) 38.57

Soil Boring Identification Number SB-4
Well Identification Number MW-12
Geol./Eng. Supervising Well Installation W.L. Schmithorst
Casing Installation Date 10/04/95
Seal Grouting Date 10/04/95
Casing Material 2" Ø PVC
Screen Material 2" Ø 0.010" slot PVC
Casing Interval (feet below surface) -2.43 to 4.35
Screened Interval (feet below surface) 4.35 to 13.77
Total Well Depth (feet below surface) 13.77
Water Level Measurement Date 10/16/95
Depth to Water (feet below top of casing) 11.02
Water Level Elevation (feet MSL) 27.55

Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class
0.0–2.0	X	5,5, 8,12	70	0.0	SAND fine to medium (80%), silt (15%), clay (5%), grayish brown (5YR3/2).	SM
2.0–4.0	X	4,5, 10,11	60	0.0	SAND fine to medium (80%), silt (15%), clay (5%), pale brown (5YR5/2).	
4.0–6.0	X	5,5, 8,9	80	0.0	Same as above.	
6.0–8.0	X	6,12, 10,10	90	>2500	SAND fine to medium (80%), clay (20%), gray (N6).	SC
8.0–10.0	X	3,5, 5,9	100	na	SAND fine to medium (100%), light gray (N7).	SM
10.0–12.0	X	4,4, 6,8	100	na	Same as above.	
12.0–15.0						
15.0–24.0					*Soil boring was terminated at 15' below ground surface.*	

Depth scale: 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0



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PARSONS ENGINEERING SCIENCE

SOIL BORING LOG AND WELL CONSTRUCTION RECORD

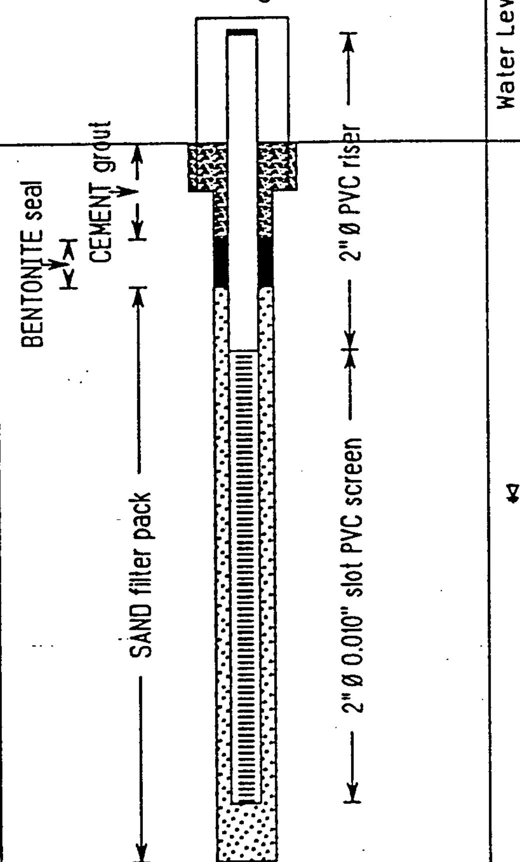
Client: AMC
Site: Fuel Hydrant System Charleston AFB
Project Identification Number: 726094-04000
Geol./Eng. Supervising Soil Boring: W.L. Schmithorst
Drilling Method (s): HSA
Sampling Method (s): na
Soil Boring Start Date: 10/04/95
Soil Boring Termination Date: 10/04/95
Drilling Company: Alliance
Borehole Diameter (inches): 8
Borehole Depth (feet below surface): 15
Surface Elevation (feet MSL): 34.58
Top of Casing Elevation (feet MSL): 36.8

Soil Boring Identification Number: MW-13
Well Identification Number: MW-13
Geol./Eng. Supervising Well Installation: W.L. Schmithorst
Casing Installation Date: 10/04/95
Seal Grouting Date: 10/04/95
Casing Material: 2" Ø PVC
Screen Material: 2" Ø 0.010" slot PVC
Casing Interval (feet below surface): -2.22 to 4.35
Screened Interval (feet below surface): 4.35 to 13.77
Total Well Depth (feet below surface): 13.77
Water Level Measurement Date: 10/16/95
Depth to Water (feet below top of casing): 9.66
Water Level Elevation (feet MSL): 27.14

Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class	Graphic Log
0.0					SAND fine to medium (80%), silt (15%), clay (5%), grayish brown (5YR3/2).	SM	
2.0	na	na	na	na			
4.0					SAND fine to medium (95%), clay (5%), light brown (5YR6/4)	SC	
6.0							
8.0					SAND fine to medium (95%), clay (5%), light medium brown (N7).		
10.0							
12.0							
14.0							
15.0					*Soil boring was terminated at 15' below ground surface.*		
16.0							
18.0							
20.0							
22.0							
24.0							

Well Diagram



PARSONS ENGINEERING SCIENCE

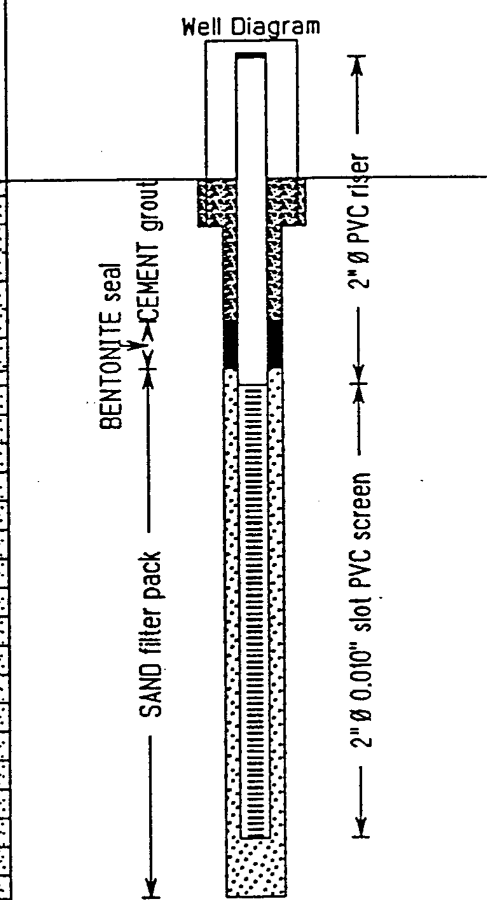
SOIL BORING LOG AND WELL CONSTRUCTION RECORD

Client AMC
Site Fuel Hydrant System Charleston AFB
Project Identification Number 726094-04000
Geol./Eng. Supervising Soil Boring W.L. Schmithorst
Drilling Method (s) HSA
Sampling Method (s) na
Soil Boring Start Date 10/04/95
Soil Boring Termination Date 10/04/95
Drilling Company Alliance
Borehole Diameter (inches) 8
Borehole Depth (feet below surface) 15
Surface Elevation (feet MSL) 38.47
Top of Casing Elevation (feet MSL) 40.96

Soil Boring Identification Number MW-14
Well Identification Number MW-14
Geol./Eng. Supervising Well Installation W.L. Schmithorst
Casing Installation Date 10/04/95
Seal Grouting Date 10/04/95
Casing Material 2" Ø PVC
Screen Material 2" Ø 0.010" slot PVC
Casing Interval (feet below surface) -2.49 to 4.35
Screened Interval (feet below surface) 4.35 to 13.77
Total Well Depth (feet below surface) 13.77
Water Level Measurement Date 10/16/95
Depth to Water (feet below top of casing) 13.20
Water Level Elevation (feet MSL) 27.76

Comments: Well casing was installed in 3" x 3" locking box.

DEPTH (feet)	Sample	Blows/6 in.	Sample %Rec.	Soil PID (ppm)	Lithologic Description	Soil Class	Graphic Log	Well Diagram	Water Level
0.0					SAND fine to medium (80%), silt (15%), clay (5%), moderate brown (5YR 4/4).	SM			
2.0	na	na	na	na					
4.0					SAND fine to medium (95%), clay (5%), light brown (5YR6/4).	SC			
6.0									
8.0									
10.0									▽
12.0									
14.0									
16.0					*Soil boring was terminated at 15' below ground surface.*				
18.0									
20.0									
22.0									
24.0									



PARSONS ENGINEERING SCIENCE

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GTGS \ 726094 \ MW-14.LOG

APPENDIX B

LABORATORY REPORTS OF ANALYSIS

GROUNDWATER ANALYTICAL DATA
FIRST ROUND - OCTOBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 10/16/95	MW-1-DUP 10/18/95	MW-3 10/16/95	MW-4 10/16/95	MW-5 10/16/95	MW-6 10/16/95	MW-7 10/17/95	MW-8 10/17/95	MW-9 10/17/95	MW-10 10/18/95	MW-11 10/18/95	MW-12 10/18/95	MW-13 10/17/95	MW-14 10/18/95
VOLATILES	UNITS:														
Benzene	µg/L	1 U	1 U	9.3	1 U	1 U	1 U	1 U	2.1	1 U	1 U	86	1 U	1 U	1 U
Ethylbenzene	µg/L	1 U	1 U	0.77 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U	25	1 U	1 U	1 U
Isopropylbenzene	µg/L	1 UJ	1 U	0.92 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Naphathalene	µg/L	1 U	1 U	1.2	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.3	1 U	1 U	1 U
Toluene	µg/L	1 U	1 U	1 U	1.1	1 U	1 U	1 U	1 U	1 U	1 U	84	1 U	1 U	1 U
Trichloroethene	µg/L	1 U	1 U	1 U	1.7	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
m,p-Xylene	µg/L	2 U	2 U	0.63 J	2 U	2 U	2 U	2 U	2 U	2 U	2 U	98	2 U	2 U	2 U
n-Butylbenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1.8	1 U	1 U	1 U
o-Xylene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	90	1 U	1 U	1 U
p-Isopropyltoluene	µg/L	1 U	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 U	1 U	1 U	1 UJ	2.2 J	1 UJ	1 U	1 UJ
VOLATILE TICs															
Benzene, 1,2,3-trimethyl-(20.84)	µg/L											37 J			
C3 sub benzene (19.30)	µg/L											27 J			
C3 sub benzene (19.76)	µg/L											25 J			
C6 Hydrocarbon (7.84)	µg/L			9.3											
C7 Hydrocarbon (9.67)	µg/L								6.4 J						
C8 Hydrocarbon (11.46)	µg/L								11 J						
C8 Hydrocarbon (11.47)	µg/L											50 J			
C8 Hydrocarbon (12.65)	µg/L											150 J			
C8 Hydrocarbon (13.30)	µg/L								5.9 J			290 J			
C8 Hydrocarbon (13.46)	µg/L								10 J						
C8 Hydrocarbon (13.49)	µg/L											240 J			
C9 Hydrocarbon (14.12)	µg/L											60 J			
C9 Hydrocarbon (15.42)	µg/L								9.6 J						
PENTANE, 2,4-DIMETHYL- (	µg/L											56 J			
Pentane, 2,2,4-Trimethyl-(11.47)	µg/L													13 J	
Pentane, 2,3,3-Trimethyl-(13.48)	µg/L													15 J	
Pentane, 2,3,4-Trimethyl-(13.30)	µg/L													8.2 J	
Pentane, 2,3-Dimethyl-(10.62)	µg/L													6.9 J	
Pentane, 2,3-dimethyl- (10.91)	µg/L											98 J			
Pentane, 2,4-Dimethyl-(9.67)	µg/L													6.5 J	
UNKNOWN OXY HYDROCA	µg/L											200 J			
Unknown Hydrocarbon (10.91)	µg/L								6.1 J						
SEMIVOLATILES															
Phenol	µg/L	10 U	10 U	2.5 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	13	10 U	10 U	10 U
bis(2-ethylhexyl)phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	16	10 U	1.7 J	10 U	2.1 J	10 U	10 U	10 U
SEMIVOLATILE TICs															
Aldol Condensation Product (4.3	µg/L											27 J			
Branched Alkane (5.49)	µg/L											530 J			
Branched Alkane (7.14)	µg/L											18 J			

GROUNDWATER ANALYTICAL DATA
FIRST ROUND - OCTOBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 10/16/95	MW-1-DUP 10/18/95	MW-3 10/16/95	MW-4 10/16/95	MW-5 10/16/95	MW-6 10/16/95	MW-7 10/17/95	MW-8 10/17/95	MW-9 10/17/95	MW-10 10/18/95	MW-11 10/18/95	MW-12 10/18/95	MW-13 10/17/95	MW-14 10/18/95
Methyl propanoic acid isomer (9.	µg/L	110 J	11 J	40 J							26 J		17 J		20 J
Trimethyl cyclopentane isomer (	µg/L											69 J			
Unknown Acid (6.28)	µg/L											49 J			
Unknown Acid (6.35)	µg/L											470 J			
Unknown Alkane (5.49)	µg/L											17 J			
Unknown Alkene (6.69)	µg/L											15 J			
Unknown Ketone (6.56)	µg/L											66 J			
Unknown Oxyhydrocarbon (18.5	µg/L											18 J			
Unknown Oxyhydrocarbon (4.06	µg/L											14 J			
Unknown Oxyhydrocarbon (4.83	µg/L											53 J			
Unknown Oxyhydrocarbon (4.95	µg/L											77 J			
Unknown Oxyhydrocarbon (5.09	µg/L											23 J			
Unknown Oxyhydrocarbon (5.31	µg/L								54 J						
Unknown Oxyhydrocarbon (5.60	µg/L											25 J			
Unknown Oxyhydrocarbon (5.60	µg/L											340 J			
Unknown Oxyhydrocarbon (5.74	µg/L													14 J	
Unknown Oxyhydrocarbon (6.04	µg/L											1300 J			
Unknown Oxyhydrocarbon (6.04	µg/L											29 J			
Unknown Oxyhydrocarbon (6.44	µg/L											17 J			
Unknown Oxyhydrocarbon (6.44	µg/L											20 J			
METALS															
Aluminum	mg/L	26 J	55 J	0.11 U	0.75 J	0.82 J	0.27 J	770 J	110 J	95 J	400 J	790 J	60 J	15 J	180 J
Antimony	mg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.025 J	0.024 U	0.024 U	0.039 J	0.024 U	0.024 U	0.024 U	0.024 U
Arsenic	mg/L	0.051 U	0.065 J	0.051 U	0.051 U	0.051 U	0.051 U	0.52	0.051 U	0.051 U	0.22 J	0.8	0.086 J	0.051 U	0.11 J
Barium	mg/L	0.13	0.12	0.031	0.014 J	0.041	0.033	2.5	0.17	0.46	0.83	1.3	0.13	0.1	0.3
Beryllium	mg/L	0.0006 U	0.0022 J	0.0006 U	0.0006 U	0.0006 U	0.0006 U	0.013	0.0015 J	0.0034 U	0.015	0.037	0.0029 J	0.0006 U	0.0039 J
Cadmium	mg/L	0.002 J	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0051	0.001 U	0.001 U	0.001 U
Calcium	mg/L	13	5.9	27	20	6.2	33	30	7.9	3.4	37	26	6.4	2.3	7.3
Chromium	mg/L	0.017	0.072	0.0036 U	0.0036 U	0.004 J	0.0036 U	0.56	0.059	0.073	0.41	0.95	0.075	0.014	0.19
Cobalt	mg/L	0.0052 U	0.098	0.0052 U	0.0052 U	0.0052 U	0.0052 U	0.069	0.0059 J	0.0059 J	0.066	1.2	0.12	0.0052 U	0.015 J
Copper	mg/L	0.0059 U	0.021	0.003 U	0.0021 U	0.0022 U	0.0021 U	0.094	0.016 J	0.02	0.082	0.31	0.024	0.0055 U	0.087
Iron	mg/L	3.3 J	22 J	3.3 J	0.16 J	0.24 J	0.041 U	120 J	18 J	27 J	90 J	330 J	23 J	6.2 J	33 J
Lead	mg/L	0.011 U	0.012 U	0.011 U	0.011 U	0.011 U	0.011 U	0.37	0.014 U	0.011 U	0.2	0.55	0.011 U	0.011 U	0.085 U
Lithium	mg/L	0.0063 U	0.014 U	0.0027 UJ	0.0027 U	0.0027 U	0.0039 U	0.15	0.01 U	0.019 J	0.1	0.3	0.015 U	0.0043 J	0.034
Magnesium	mg/L	0.72 J	2.4 J	1.3	0.88 J	0.54 J	0.72 J	17 J	3.4 J	5.1 J	13 J	27 J	2.6 J	1.9	5.7 J
Manganese	mg/L	0.02	0.076	0.027	0.0012 J	0.0059 J	0.0079 J	0.46	0.063	0.12	0.29	0.7	0.079	0.044	0.15
Molybdenum	mg/L	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.021 J	0.013 U	0.013 U	0.013 J	0.042 J	0.013 U	0.013 U	0.013 U
Nickel	mg/L	0.011 U	0.053	0.011 U	0.011 U	0.011 U	0.011 U	0.13	0.011 U	0.016 J	0.06	0.73	0.065	0.011 U	0.021 J
Phosphorus	mg/L	0.061 UJ	0.24 J	0.061 UJ	0.061 UJ	0.061 UJ	0.36 J	2.3	0.061 U	0.18 U	0.76	1.2	0.3 J	0.061 U	0.18 U
Potassium	mg/L	1 J	2.9 J	1.3 J	2.2 J	1 J	1.5 J	13	2.7 J	3.4	10	27	3	1.6 J	6.4
Selenium	mg/L	0.034 U	0.034 U	0.034 U	0.034 U	0.034 U	0.034 U	0.1 J	0.034 U	0.034 U	0.04 J	0.18 J	0.034 U	0.034 U	0.034 U

GROUNDWATER ANALYTICAL DATA
FIRST ROUND - OCTOBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 10/16/95	MW-1-DUP 10/18/95	MW-3 10/16/95	MW-4 10/16/95	MW-5 10/16/95	MW-6 10/16/95	MW-7 10/17/95	MW-8 10/17/95	MW-9 10/17/95	MW-10 10/18/95	MW-11 10/18/95	MW-12 10/18/95	MW-13 10/17/95	MW-14 10/18/95
Sodium	mg/L	1.4	3.5	2.2	2.9	1.7	6.4	2.3	4.3	1.7	14	5.5	3.6	8.9	2
Strontium	mg/L	0.0036 J	0.066	0.027	0.034	0.0068 J	0.23	0.32	0.068	0.069	0.32	0.47	0.071	0.04	0.12
Thallium	mg/L	0.043 U	0.043 U	0.043 U	0.043 U	0.043 U	0.043 U	0.043 U	0.043 U	0.043 U	0.043 U	0.16 J	0.043 U	0.043 U	0.043 U
Vanadium	mg/L	0.021 J	0.09	0.0018 U	0.0035 J	0.0035 J	0.0028 J	0.39	0.057	0.088	0.59	1.4	0.1	0.012 J	0.2
Zinc	mg/L	0.019 U	0.19	0.0064 U	0.0076 U	0.0092 U	0.0087 U	0.37	0.043	0.075	0.24	1.4	0.22	0.016 U	0.099
OTHER															
TPH-JP4	µg/L		100 UJ			100 UJ						4800 J	100 UJ		
Methane	mg/L	12	29	1100	12	11	12	12	120	12	5.6 U	430	31	500	20
Nitrogen, Nitrate-Nitrite	µg/L	20	20	70	910	30	110	20	8 U	10	50	20	10	30	20
Sulfate	mg/L	5	14	5	3	8	5	15	14	9	39	13	9	7	11

U = Not detected.
J = Estimated value.

GROUNDWATER ANALYTICAL DATA
SECOND ROUND - NOVEMBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 11/13/95	MW-1-DUP 11/14/95	MW-3 11/13/95	MW-4 11/13/95	MW-5 11/13/95	MW-6 11/13/95	MW-7 11/14/95	MW-8 11/14/95	MW-9 11/14/95	MW-10 11/15/95	MW-11 11/14/95	MW-12 11/14/95	MW-13 11/14/95	MW-14 11/14/95
VOLATILES	UNITS:														
Benzene	µg/L	1 U	1 U	3	1 U	1 U	1 U	1 U	1.9 J	1 U	1 U	2 J	1 U	1 U	1 U
Chlorobenzene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.46 J	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 J	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	µg/L	1 U	1 U	0.92 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.9 J	1 U	1 U	1 U
Toluene	µg/L	1 U	1 U	1 U	1 U	0.63 J	1 U	1 U	0.74 J	1 U	1 U	1.8 J	1 U	1 U	1 U
m,p-Xylene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	10	1 U	1 U	1 U
o-Xylene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	3	1 U	1 U	1 U
VOLATILE TICs															
BUTANE, 2,3-DIMETHYL- (8.	µg/L								7.5 J						
BUTANE, 2,3-DIMETHYL- (8.	µg/L													9.9 J	
C7 Hydrocarbon (10.05)	µg/L								6.2 J						
C7 Hydrocarbon (10.06)	µg/L											7.1 J			
C7 Hydrocarbon (11.28)	µg/L								17 J					9.2 J	
C7 Hydrocarbon (11.29)	µg/L											21 J			
C7 Oxygenated Hydrocarbon (15	µg/L								5.9 J						
C8 Hydrocarbon (11.83)	µg/L								17 J			54 J		10 J	
C8 Hydrocarbon (13.00)	µg/L											18 J			
C8 Hydrocarbon (13.63)	µg/L													6.3 J	
C8 Hydrocarbon (13.64)	µg/L								8.4 J			32 J			
C8 Hydrocarbon (13.82)	µg/L											49 J		13 J	
C8 Hydrocarbon (13.83)	µg/L								13 J						
C9 Hydrocarbon (14.42)	µg/L											25 J			
Pentane, 3-methyl- (8.70)	µg/L			7.3 J											
SEMIVOLATILES															
Acenaphthene	µg/L	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Acenaphthylene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aniline	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Anthracene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(ghi)perylene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzoic acid	µg/L	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ
Benzyl alcohol	µg/L	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Bis(2-chloroisopropyl)ether	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butyl benzyl phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	µg/L	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-Chloroaniline	µg/L	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U

GROUNDWATER ANALYTICAL DATA
SECOND ROUND - NOVEMBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 11/13/95	MW-1-DUP 11/14/95	MW-3 11/13/95	MW-4 11/13/95	MW-5 11/13/95	MW-6 11/13/95	MW-7 11/14/95	MW-8 11/14/95	MW-9 11/14/95	MW-10 11/15/95	MW-11 11/14/95	MW-12 11/14/95	MW-13 11/14/95	MW-14 11/14/95
2-Chloronaphthalene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chlorophenyl phenyl ether	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butyl phthalate	µg/L	2.1 J	10 U	10 U	10 U	10 U	3.2 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-octyl phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenz(a,h)anthracene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	µg/L	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
2,4-Dichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethyl phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dimethyl phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4,6-Dinitro-2-methylphenol	µg/L	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2,4-Dinitrophenol	µg/L	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 UJ	50 U	50 U	50 U
2,6-Dinitrotoluene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrotoluene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodi-n-propylamine	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U
N-Nitrosodiphenylamine	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	µg/L	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
3-Nitroaniline	µg/L	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitroaniline	µg/L	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Nitrobenzene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitrophenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitrophenol	µg/L	R	50 U	R	R	R	R	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Pentachlorophenol	µg/L	R	50 U	R	R	R	R	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U

GROUNDWATER ANALYTICAL DATA
SECOND ROUND - NOVEMBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 11/13/95	MW-1-DUP 11/14/95	MW-3 11/13/95	MW-4 11/13/95	MW-5 11/13/95	MW-6 11/13/95	MW-7 11/14/95	MW-8 11/14/95	MW-9 11/14/95	MW-10 11/15/95	MW-11 11/14/95	MW-12 11/14/95	MW-13 11/14/95	MW-14 11/14/95
Phenanthrene	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	µg/L	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
1,2,4-Trichlorobenzene	µg/L	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
2,4,6-Trichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-chloroethoxy)methane	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-chloroethyl)ether	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U
bis(2-ethylhexyl)phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	1.5 J	1.1 J	2.5 J	10 U	6 J	2.3 J	10 U	10 U
SEMIVOLATILE TICs															
Unknown Acid (10.58)	µg/L								5.7 J						
Unknown Acid (5.24)	µg/L											12 J			
Unknown Acid (5.29)	µg/L								45 J						
Unknown Acid (5.65)	µg/L											25 J			
Unknown Alcohol (4.37)	µg/L											4.7 J			
Unknown Alcohol (4.90)	µg/L												6.3 J		
Unknown Alcohol (5.63)	µg/L													11 J	
Unknown Alkane (4.60)	µg/L											5.9 J			
Unknown Alkane (4.61)	µg/L		4.5 J												
Unknown Alkane (4.90)	µg/L		5.2 J												
Unknown Alkane (5.21)	µg/L		4.2 J										6.2 J		
Unknown Alkane (5.38)	µg/L		4.3 J										6.2 J		
Unknown Alkane (6.51)	µg/L		6.1 J										5.9 J		
Unknown Alkane (6.51)	µg/L		6.1 J										8.7 J		
Unknown Alkane (7.09)	µg/L		4.5 J										7.4 J		
Unknown Alkane (7.32)	µg/L											4 J			
Unknown Alkane (7.33)	µg/L		5.5 J										8.2 J		
Unknown Alkane (7.96)	µg/L												5.3 J		
Unknown Alkane (8.16)	µg/L		5.7 J										6.2 J		
Unknown Alkane (8.65)	µg/L												4.8 J		
Unknown Oxy Cyclic Hydrocarb	µg/L								6 J			4.2 J			
Unknown Oxy Cyclic Hydrocarb	µg/L												5.7 J		
Unknown Oxy Hydrocarbon (5.9	µg/L											4.6 J			
Unknown alkyl alkene (5.99)	µg/L								7.5 J						
Unsaturated Acid (9.40)	µg/L						4.4 J								
METALS															
Aluminum	mg/L	21 J	140 J	13 J	8.1 J	5.3 J	0.44 J	400 J	86 J	46 J	45 J	330 J	98 J	79 J	59 J
Antimony	mg/L	0.024 U	0.024 U	0.044	0.024 U	0.025	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.051	0.024 U	0.024 U	0.044
Arsenic	mg/L	0.051 U	0.051 U	0.051 U	0.051 U	0.079	0.051 U	0.37	0.051 U	0.051 U	0.051 U	0.31	0.062	0.051 U	0.051 U
Barium	mg/L	0.083 J	0.25 J	0.049 J	0.036 J	0.061 J	0.034 J	1.3 J	0.11 J	0.17 J	0.15 J	0.55 J	0.18 J	0.3 J	0.12 J
Beryllium	mg/L	0.0006 U	0.0059	0.0006 U	0.0006 U	0.0006 U	0.0006 U	0.0065	0.0007	0.0012	0.0014	0.015	0.0038	0.0013	0.0014

GROUNDWATER ANALYTICAL DATA
SECOND ROUND - NOVEMBER 1995
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	MW-1 11/13/95	MW-1-DUP 11/14/95	MW-3 11/13/95	MW-4 11/13/95	MW-5 11/13/95	MW-6 11/13/95	MW-7 11/14/95	MW-8 11/14/95	MW-9 11/14/95	MW-10 11/15/95	MW-11 11/14/95	MW-12 11/14/95	MW-13 11/14/95	MW-14 11/14/95
Calcium	mg/L	13 J	8.3 J	25 J	19 J	5.6 J	33 J	18 J	5.8 J	1.9 J	25 J	11 J	6.7 J	2.8 J	4.5 J
Chromium	mg/L	0.013 J	0.17 J	0.01 J	0.0065 J	0.0056 J	0.0037 U	0.3 J	0.052 J	0.037 J	0.049 J	0.42 J	0.12 J	0.057 J	0.062 J
Cobalt	mg/L	0.0053 U	0.19	0.0053 U	0.0053 U	0.0053 U	0.0053 U	0.027	0.0053 U	0.008	0.0061	0.44	0.14	0.0069	0.0053 U
Copper	mg/L	0.0035	0.064	0.003	0.0022	0.0021 U	0.0021 U	0.054	0.015	0.0082	0.0095	0.14	0.039	0.017	0.025
Iron	mg/L	2.8 J	51 J	5.1 J	1.3 J	1.9 J	0.21 J	59 J	16 J	13 J	16 J	130 J	35 J	19 J	14 J
Lead	mg/L	0.017	0.11	0.012 U	0.012 U	0.012 U	0.012 U	0.17	0.027	0.012 U	0.021	0.21	0.073	0.026	0.028
Lithium	mg/L	0.0043	0.038	0.0032	0.0027 U	0.0027 U	0.0047	0.07	0.0079	0.0098	0.011	0.12	0.027	0.015	0.013
Magnesium	mg/L	0.67 J	5.4 J	1.6 J	1.1 J	1.1 J	0.82 J	9.5 J	3.1 J	3.1 J	4.1 J	12 J	3.9 J	4.3 J	2.5 J
Manganese	mg/L	0.017 J	0.15 J	0.036 J	0.012 J	0.018 J	0.0065 J	0.23 J	0.047 J	0.061 J	0.08 J	0.29 J	0.11 J	0.099 J	0.063 J
Molybdenum	mg/L	0.018 J	0.013 UJ	0.013 UJ	0.013 U	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ	0.013 UJ
Nickel	mg/L	0.011 U	0.12	0.011 U	0.011 U	0.011 U	0.011 U	0.058 U	0.011 U	0.011 U	0.011 U	0.27	0.074	0.011 U	0.011 U
Phosphorus	mg/L	0.11 U	1.1	0.11 U	0.089 U	0.11 U	0.33 U	3	0.42 U	0.42 U	0.33 U	1.9	0.81	0.4 U	0.44 U
Potassium	mg/L	1.1	6	1.7	2.7	1.4	1.3	7.2	2.5	2.6	2.6 U	13	4.5	3.4	3
Selenium	mg/L	0.038 U	0.035 U	0.038 U	0.057 J	0.035 U	0.035 U	0.035 U	0.046	0.11 U	0.036 U	0.035 U	0.035 U	0.089 U	0.035 U
Sodium	mg/L	1.2	3.4	2	2.7	1.7	6.6	2.2	3.9	1.5	33	2.7	3.4	8.9	1.9
Strontium	mg/L	0.0034	0.11	0.024	0.04	0.011	0.24	0.17	0.054	0.036	0.12	0.2	0.083	0.066	0.06
Vanadium	mg/L	0.019	0.22	0.014	0.01	0.0071	0.0033	0.21	0.053	0.043	0.068	0.62	0.15	0.06	0.069
Zinc	mg/L	0.014 U	0.4 J	0.01 U	0.013 U	0.011 U	0.012 U	0.2 J	0.038 U	0.037 U	0.031	0.65 J	0.27 J	0.05 J	0.038 U
OTHER															
TPH-JP4	µg/L		380 J			100 UJ						620 J	430 J		
Nitrogen, Nitrate-Nitrite	µg/L	18	13	99	860	73	93	20	9.7	8 U	8.1	19	9.9	8 U	11
Sulfate	mg/L	4	7.8	5.6	4.2	9.1	6	8.6	8.3	7.4	68	6.9	7.1	3.4	9.3

U = Not detected.

J = Estimated value.

R = Unusable data.

SURFACE WATER ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: / DATE:	SW-1 10/03/95	SW-1-DUP1 10/03/95	SW-1-DUP2 10/03/95	SW-2 10/03/95	SW-3 10/03/95	SW-4 10/03/95	SW-5 10/03/95	SW-6 10/03/95
VOLATILES	UNITS:								
Bromobenzene	µg/L	R	R	R	R	R	R	R	R
2-Chlorotoluene	µg/L	R	R	R	R	R	R	R	R
4-Chlorotoluene	µg/L	R	R	R	R	R	R	R	R
1,2-Dichlorobenzene	µg/L	R	R	R	R	R	R	R	R
1,3-Dichlorobenzene	µg/L	R	R	R	R	R	R	R	R
1,3-Dichloropropane	µg/L	R	R	R	R	R	R	R	R
2,2-Dichloropropane	µg/L	R	R	R	R	R	R	R	R
1,1-Dichloropropene	µg/L	R	R	R	R	R	R	R	R
Ethylbenzene	µg/L	1 U	1 U	1 U	1.1	1 U	1 U	1 U	1 U
Hexachlorobutadiene	µg/L	R	R	R	R	R	R	R	R
Isopropylbenzene	µg/L	R	R	R	R	R	R	R	R
Naphathalene	µg/L	R	R	R	R	R	R	R	R
1,2,3-Trichlorobenzene	µg/L	R	R	R	R	R	R	1 U	R
1,2,4-Trichlorobenzene	µg/L	R	R	R	R	R	R	R	R
1,1,1-Trichloroethane	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	R	1 U
1,2,4-Trimethylbenzene	µg/L	R	R	R	R	R	R	R	R
1,3,5-Trimethylbenzene	µg/L	R	R	R	R	R	R	R	R
m,p-Xylene	µg/L	2 U	2 U	2 U	2 U	1.2 J	2 U	2 U	2 U
n-Butylbenzene	µg/L	R	R	R	R	R	R	R	R
n-Propylbenzene	µg/L	R	R	R	R	R	R	R	R
p-Isopropyltoluene	µg/L	R	R	R	R	R	R	R	R
sec-Butylbenzene	µg/L	R	R	R	R	R	R	R	R
tert-Butylbenzene	µg/L	R	R	R	R	R	R	R	R
SEMIVOLATILES									
Benzo(a)pyrene	µg/L	10 U	1.4 J	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	µg/L	10 U	2.6 J	10 U	10 U	10 U	10 UJ	10 U	10 U
Benzyl alcohol	µg/L	20 U	20 U	20 U	20 U	20 U	R	20 U	20 U
4-Chloro-3-methylphenol	µg/L	20 U	20 U	20 U	20 U	20 U	R	20 U	20 U
2-Chlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
Chrysene	µg/L	10 U	1.9 J	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butyl phthalate	µg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
2,4-Dimethylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
4,6-Dinitro-2-methylphenol	µg/L	50 U	50 U	50 U	50 U	50 U	R	50 U	50 U
2,4-Dinitrophenol	µg/L	50 U	50 U	50 U	50 U	50 U	R	50 U	50 U
Fluoranthene	µg/L	10 U	4.3 J	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
4-Methylphenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
2-Nitrophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
4-Nitrophenol	µg/L	50 UJ	50 U	50 UJ	50 UJ	50 UJ	R	50 UJ	50 UJ
Pentachlorophenol	µg/L	50 U	50 U	50 U	50 U	50 U	R	50 U	50 U
Phenanthrene	µg/L	10 U	2.2 J	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
Pyrene	µg/L	10 U	3.6 J	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
2,4,5-Trichlorophenol	µg/L	10 U	10 U	10 U	10 U	10 U	R	10 U	10 U
bis(2-ethylhexyl)phthalate	µg/L	10 U	6 J	10 U	10 U	10 U	10 U	10 U	10 U
SEMIVOLATILE TICs									
Unknown Alkane (15.89)	µg/L		11 J						
Unknown Alkane (16.18)	µg/L		13 J						
Unknown Alkane (16.31)	µg/L		9.3 J						
Unknown Alkane (16.54)	µg/L		23 J						

SURFACE WATER ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	SW-1 10/03/95	SW-1-DUP1 10/03/95	SW-1-DUP2 10/03/95	SW-2 10/03/95	SW-3 10/03/95	SW-4 10/03/95	SW-5 10/03/95	SW-6 10/03/95
METALS									
Aluminum	mg/L	0.56 J	0.1 J	1.8 J	0.47 J	0.61 J	7.8 J	0.19 J	0.24 J
Calcium	mg/L	14	20	20	17	18	4.8	20	19
Chromium	mg/L	0.0036 U	0.0036 U	0.0036 U	0.0036 U	0.0036 U	0.0053	0.0036 U	0.0036 U
Copper	mg/L	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0096	0.0021 U	0.0021 U
Iron	mg/L	1.4 J	2.5 J	4.1 J	1.5 J	1.6 J	17 J	1.6 J	3.2 J
Lithium	mg/L	0.0027 U	0.0039	0.0042	0.0027 U	0.0027 U	0.0027	0.0027 U	0.0031
Magnesium	mg/L	1.7	2	2	1.9	1.9	1.7	2.2	2
Manganese	mg/L	0.024 J	0.032 J	0.034 J	0.023 J	0.023 J	0.055 J	0.019 J	0.032 J
Phosphorus	mg/L	0.11	0.21	0.24	0.17	0.17	0.64	0.17	0.19
Potassium	mg/L	0.76 J	1 J	1 J	1.1 J	0.94 J	1.2 J	0.83 J	0.79 J
Sodium	mg/L	4.4	7.4	7.4	4.9	5	2.8	7	7.3
Strontium	mg/L	0.057	0.1	0.1	0.069	0.072	0.025	0.1	0.097
Vanadium	mg/L	0.0028 UJ	0.0018 UJ	0.0024 UJ	0.0018 UJ	0.0018 UJ	0.013	0.0018 UJ	0.0018 U
Zinc	mg/L	0.0072	0.0036 U	0.0054	0.0036 U	0.0067	0.029	0.0036 U	0.0036 U
OTHER									
TPH-JP4	µg/L	100 UJ	570 J	110 J	100 UJ	100 UJ	290 J	160 J	100 UJ
Nitrogen, Nitrate-Nitrite	µg/L	110		10	20	30	8 U	20	10
Sulfate	mg/L	10		10	14	16	9	10	9

U = Not detected.
J = Estimated value.
R = Unusable data.

SEDIMENT ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	SS-1 10/03/95	SS-2 10/04/95	SS-2-DUP 10/03/95	SS-3 10/04/95	SS-4 10/04/95	SS-5 10/04/95	SS-6 10/04/95
VOLATILES	UNITS:							
Methylene chloride	µg/Kg	6.6 U	6.4 U	2.6 J	6.4 U	6.6 U	6.6 U	6.4 U
Toluene	µg/Kg	6.6 U	6.4 U	6.2 U	6.4 U	6.6 U	0.3 J	6.4 U
Trichloroethene	µg/Kg	1.2 J	1.2 J	1.1 J	4.2 J	2.9 J	0.86 J	5.2 J
Trichlorofluoromethane	µg/Kg	6.6 U	6.4 U	9.1	6.4 U	6.6 U	6.6 U	6.4 U
m,p-Xylene	µg/Kg	6.6 U	6.4 U	6.2 U	6.4 U	6.6 U	0.4 J	6.4 U
VOLATILE TICs								
C13-Hydrocarbon (26.21)	µg/Kg						30 J	
C7-Hydrocarbon (10.91)	µg/Kg						11 J	
Unknown-Hydrocarbon (23.66)	µg/Kg						10 J	
Unknown-Hydrocarbon (23.92)	µg/Kg						18 J	
Unknown-Hydrocarbon (24.67)	µg/Kg						7.4 J	
Unknown-Hydrocarbon (24.79)	µg/Kg						33 J	
Unknown-Hydrocarbon (25.14)	µg/Kg						16 J	
Unknown-Hydrocarbon (25.30)	µg/Kg						11 J	
Unknown-Hydrocarbon (25.40)	µg/Kg						10 J	
Unknown-Hydrocarbon (26.00)	µg/Kg						8.2 J	
Unknown-Oxy-Hydrocarbon (24.52)	µg/Kg						11 J	
SEMIVOLATILES								
Benzo(a)anthracene	µg/Kg	310 J	700 J	320 J	680 J	870 UJ	870 U	850 UJ
Benzo(a)pyrene	µg/Kg	330 J	550 J	250 J	640 J	870 UJ	870 U	850 UJ
Benzo(b)fluoranthene	µg/Kg	500 J	850	350 J	960	870 UJ	870 U	1040 J
Benzo(ghi)perylene	µg/Kg	310 J	380 J	820 U	540 J	870 UJ	870 U	780 J
Benzo(k)fluoranthene	µg/Kg	870 U	260 J	820 U	360 J	870 UJ	870 U	850 UJ
Chrysene	µg/Kg	400 J	710 J	320 J	750 J	870 UJ	870 U	840 J
Fluoranthene	µg/Kg	840 J	1500	910	1600	870 U	870 U	1540 J
Indeno(1,2,3-cd)pyrene	µg/Kg	350 J	430 J	820 U	610 J	870 UJ	870 U	850 UJ
Phenanthrene	µg/Kg	360 J	600 J	700 J	960	870 U	870 U	960 J
Pyrene	µg/Kg	650 J	1300	700 J	1400	870 UJ	870 U	2000 J
SEMIVOLATILE TICs								
Aldol Condensation Product (4.42)	µg/Kg	3000 AJB	2500 AJB		3100 J	2200 AJB	1900 AJB	2000 AJB
Aldol Condensation Product (4.43)	µg/Kg			2400 AJB				
Aliphatic Alcohol (13.20)	µg/Kg	510 J		190 J		450 J	340 J	
Aliphatic Alcohol (15.13)	µg/Kg					540 J		
Alkyl Benzene (15.13)	µg/Kg			250 J				
Halogenated cyclohexane (8.95)	µg/Kg	390 J						
Hexadecanoic Acid (12.47)	µg/Kg				320 J			
PNA (12.87)	µg/Kg				280 J			
PNA (14.14)	µg/Kg			170 J				
PNA (14.27)	µg/Kg			170 J				
PNA (15.14)	µg/Kg				320 J			
PNA (18.26)	µg/Kg	360 J	400 J	210 J				
PNA (18.27)	µg/Kg				450 J			
PNA (23.06)	µg/Kg			170 J				
Polycyclic hydrocarbon (21.18)	µg/Kg					520 J		
Polycyclic hydrocarbon (21.64)	µg/Kg							860 J
Steroidal Compound (22.70)	µg/Kg					830 J		
Steroidal Compound (23.16)	µg/Kg					1300 J		
Steroidal Compound (24.35)	µg/Kg	790 J						
Steroidal Compound (24.36)	µg/Kg					1800 J		
Tetrahydronaphthalene isomer (9.52)	µg/Kg	380 J						
Unknown Alkane (10.64)	µg/Kg					380 J		
Unknown Alkane (15.81)	µg/Kg	430 J					440 J	
Unknown Alkane (15.89)	µg/Kg						420 J	1160 J

SEDIMENT ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DATE:	SS-1 10/03/95	SS-2 10/04/95	SS-2-DUP 10/03/95	SS-3 10/04/95	SS-4 10/04/95	SS-5 10/04/95	SS-6 10/04/95
Unknown Alkane (16.00)	µg/Kg	490 J					680	1940 J
Unknown Alkane (16.08)	µg/Kg						330 J	740 J
Unknown Alkane (16.16)	µg/Kg						310 J	
Unknown Alkane (16.29)	µg/Kg	550 J			290 J		670 J	1160 J
Unknown Alkane (16.44)	µg/Kg						400 J	
Unknown Alkane (16.67)	µg/Kg	490 J			230 J		840 J	600 J
Unknown Alkane (17.89)	µg/Kg					550 J		
Unknown Alkane (18.94)	µg/Kg							960 J
Unknown Oxyhydrocarbon (12.00)	µg/Kg				230 J			
Unknown Oxyhydrocarbon (15.07)	µg/Kg			170 J				
Unknown Oxyhydrocarbon (4.18)	µg/Kg		180 J		200 AJB			
Unknown Oxyhydrocarbon (4.19)	µg/Kg			180 J				
Unknown Oxyhydrocarbon (4.98)	µg/Kg		190 J	190 J	260 J			
Unsaturated Acid (12.37)	µg/Kg							720 J
METALS								
Aluminum	mg/Kg	3400 J	1900 J	3400 J	3200 J	28000 J	3600 J	2400 J
Arsenic	mg/Kg	6.9 U	6.9 U	6.9 U	6.9 U	44	6.9 U	6.9 U
Barium	mg/Kg	9.9	4.2	10	7.7	65	8.6	41
Cadmium	mg/Kg	0.078 U	0.078 U	0.078 U	0.078 U	0.078 U	0.16	0.26
Calcium	mg/Kg	1200 J	660 J	14000 J	2900 J	180 J	400 J	2800 J
Chromium	mg/Kg	4.1	2.4	4.7	3.7	15	4.4	5.2
Cobalt	mg/Kg	1	0.42 U	0.79	0.74	1.3	0.42 U	0.42 U
Iron	mg/Kg	2400	1000	2000 U	1700	2600	1800	2900
Lead	mg/Kg	1.7	1.9 J	2.6	4.6 J	13	2.6 J	4.7 J
Lithium	mg/Kg	3.6	0.71	2.4	1.5	9.2	2.1	2.4
Magnesium	mg/Kg	370	64	460	140	360	120	220
Manganese	mg/Kg	29	2.9	25	8.3	20	7	18
Nickel	mg/Kg	1.6	1.3	2.2	1.2	4.5	1.6	1.3
Phosphorus	mg/Kg	130	220	150	310	4.1 U	65	310
Potassium	mg/Kg	360	84 U	240 J	130	420	120	190
Strontium	mg/Kg	3.4 J	3.6 J	12 J	7 J	5.5 J	2.6 J	9.1 J
Vanadium	mg/Kg	5.4	2.7	4.9	4.7	13	7.8	9.7
Zinc	mg/Kg	11	8.4	10	8.2	13	11	60
OTHER								
TPH-JP4	mg/Kg	13	15 J	12	20 J	13 U	18	17
Solids, Percent	%	76	78.4	80.2	78.4	75.8	75.7	78.1

U = Not detected.
J = Estimated value.

SUBSURFACE SOIL ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DEPTH: DATE:	SB-01 04-06' 10/03/95	SB-01-DUP 06-08' 10/03/95	SB-02 06-08' 10/03/95	SB-03 04-06' 10/03/95	SB-04 04-06' 10/04/95	SB-05 04-06' 10/04/95	SB-06 04-06' 10/04/95	SB-07 04-06' 10/04/95	SB-08 04-06' 10/04/95	SB-09 06-08' 10/04/95	SB-10 04-06' 10/04/95	SB-11 06-08' 10/04/95
VOLATILES	UNITS:												
Benzene	µg/Kg	5.7 U	5.5 U	6.2 U	1.7 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Ethylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	17	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Isopropylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	2 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Naphathalene	µg/Kg	5.7 U	5.5 U	6.2 U	25	0.8 J	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
1,1,2,2-Tetrachloroethane	µg/Kg	5.7 U	5.5 U	6.2 U	1.1 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Toluene	µg/Kg	5.7 U	5.5 U	6.2 U	2.7 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
1,2,4-Trichlorobenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	0.7 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
1,1,1-Trichloroethane	µg/Kg	5.7 U	5.5 U	6.2 U	1.3 J	1.9 J	5.6 U	2.1 J	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
Trichloroethene	µg/Kg	7.9	0.65 J	2.2 J	7.9	9.9	8.2	18	4.3 J	14	4.2 J	5.5 U	1.3 J
1,2,4-Trimethylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	34	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
1,3,5-Trimethylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	43	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
m,p-Xylene	µg/Kg	5.7 U	5.5 U	6.2 U	110	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
n-Butylbenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	1.1 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
n-Propylbenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	0.63 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
o-Xylene	µg/Kg	5.7 U	5.5 U	6.2 U	56	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
p-Isopropyltoluene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 J	6.4 U	0.68 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
sec-Butylbenzene	µg/Kg	5.7 U	5.5 UJ	6.2 U	6.1 U	6.4 U	0.64 J	5.6 U	5.9 U	6.4 UJ	6.2 U	5.5 UJ	7.6 U
tert-Butylbenzene	µg/Kg	5.7 U	5.5 U	6.2 U	2.7 J	6.4 U	5.6 U	5.6 U	5.9 U	6.4 U	6.2 U	5.5 U	7.6 U
VOLATILE TICs													
Acetone	µg/Kg				100								
Acetone (6.97)	µg/Kg											330	
Benzene C3-sustituted (18.96)	µg/Kg					12 J							
Benzene, C3-sustituted (20.08)	µg/Kg				72 J								
Benzene, C3-sustituted (20.85)	µg/Kg				83 J								
Benzene, C4-sustituted (21.37)	µg/Kg				52 J								
Benzene, C6-substututed (24.39)	µg/Kg						13 J						
Benzene, c4-sustituted (23.67)	µg/Kg				49 J								
Benzene, ethyl-methyl-isomer (19.27	µg/Kg				49 J								
C11-Hydrocarbon (19.48)	µg/Kg						24 J						
C11-Hydrocarbon (20.49)	µg/Kg						30 J						
C11-Hydrocarbon (20.95)	µg/Kg						26 J						
C7-Hydrocarbon (13.30)	µg/Kg					11 J							
C8-Hydrocarbon (13.49)	µg/Kg					17 J							
C8-Hydrocarbon (17.16)	µg/Kg						12 J						
C8-hydrocarbon (11.46)	µg/Kg				160 J						8.8 J		
C8-hydrocarbon (12.66)	µg/Kg				37 J								
C8-hydrocarbon (13.30)	µg/Kg				93 J						7 J		
C8-hydrocarbon (13.48)	µg/Kg										14 J		
C8-hydrocarbon (13.49)	µg/Kg				150 J								
C8-hydrocarbon (14.11)	µg/Kg					17 J					7.7 J		
C8-hydrocarbon (14.12)	µg/Kg				92 J								

SUBSURFACE SOIL ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DEPTH: DATE:	SB-01 04-06' 10/03/95	SB-01-DUP 06-08' 10/03/95	SB-02 06-08' 10/03/95	SB-03 04-06' 10/03/95	SB-04 04-06' 10/04/95	SB-05 04-06' 10/04/95	SB-06 04-06' 10/04/95	SB-07 04-06' 10/04/95	SB-08 04-06' 10/04/95	SB-09 06-08' 10/04/95	SB-10 04-06' 10/04/95	SB-11 06-08' 10/04/95
C9-hydrocarbon (16.42)	µg/Kg										89 J		
C9-hydrocarbon (16.80)	µg/Kg					8.6 J							
2-Propanol (7.44)	µg/Kg											74 J	
Unknown Cyclic Hydrocarbon (21.3	µg/Kg					7.1 J							
Unknown Hydrocarbon (20.51)	µg/Kg					8.6 J							
Unknown, hydrocarbon (21.64)	µg/Kg				66 J								
Unknown-Hydrocarbon (19.02)	µg/Kg						21 J						
Unknown-Hydrocarbon (23.96)	µg/Kg						40 J						
Unknown-Hydrocarbon (24.80)	µg/Kg						13 J						
Unknown-Hydrocarbon (26.22)	µg/Kg						17 J						
Unknown-Oxy-Hydrocarbon (13.78)	µg/Kg					7.2 J							
Unknown-Oxy-Hydrocarbon (15.42)	µg/Kg				70 J								
Unknown-Oxy-Hydrocarbon (18.42)	µg/Kg										7.7 J		
Unknown-Oxy-Hydrocarbon (19.09)	µg/Kg										7.5 J		
Unknown-Oxy-Hydrocarbon (19.89)	µg/Kg					7.5 J							
Unknown-Oxy-Hydrocarbon (22.56)	µg/Kg						12 J						
Unknown-Oxy-Hydrocarbon (22.96)	µg/Kg						18 J						
SEMIVOLATILES													
Benzo(a)anthracene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	790 J	850 U	810 U	730 U	1000 U
Benzo(a)pyrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	850 J	850 U	810 U	730 U	1000 U
Benzo(b)fluoranthene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	170 J	1400 J	850 U	810 U	730 U	1000 U
Benzo(ghi)perylene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	800 J	850 U	810 U	730 U	1000 U
Benzo(k)fluoranthene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	500 J	850 U	810 U	730 U	1000 U
Chrysene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	1000 J	850 U	810 U	730 U	1000 U
Fluoranthene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	1800	850 U	810 U	730 U	1000 U
Indeno(1,2,3-cd)pyrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	870 J	850 U	810 U	730 U	1000 U
Phenanthrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	990 J	850 U	810 U	730 U	1000 U
Pyrene	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	210 J	1900	850 U	810 U	730 U	1000 U
bis(2-ethylhexyl)phthalate	µg/Kg	750 U	720 U	820 U	810 U	840 U	740 U	740 U	530 J	850 U	810 U	730 U	1000 U
SEMIVOLATILE TICs													
Alcohol (15.23)	µg/Kg				210 J								
Aldol Condensation Product (4.19)	µg/Kg					220 AJ							
Aldol Condensation Product (4.42)	µg/Kg					3400 AJB		2900 AJB					230 AJB
Aldol Condensation Product (4.43)	µg/Kg								3800 AJB	3100 AJB			
Aldol Condensation Product (4.47)	µg/Kg	1400 AJB	2100				1600 AJB					2400 AJB	
Aldol Condensation Product (4.48)	µg/Kg			3500 AJB	3100 AJB						2900 AJB		
Aldol Condensation Product (4.98)	µg/Kg					280 AJB							
Aldol Condensation Product (5.02)	µg/Kg			200 AJ									
Aldol Condensation Product (5.03)	µg/Kg				360 AJ								
Aliphatic Alcohol (13.20)	µg/Kg												2700 J
Aliphatic Alcohol (15.14)	µg/Kg									270 J			
Aliphatic Alcohol (16.32)	µg/Kg									190 J			

SUBSURFACE SOIL ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DEPTH: DATE:	SB-01 04-06' 10/03/95	SB-01-DUP 06-08' 10/03/95	SB-02 06-08' 10/03/95	SB-03 04-06' 10/03/95	SB-04 04-06' 10/04/95	SB-05 04-06' 10/04/95	SB-06 04-06' 10/04/95	SB-07 04-06' 10/04/95	SB-08 04-06' 10/04/95	SB-09 06-08' 10/04/95	SB-10 04-06' 10/04/95	SB-11 06-08' 10/04/95
Alkane (4.29)	µg/Kg				180 J								
Alkane (5.27)	µg/Kg				190 J								
Cyclo Aromatic Compound(23.30)	µg/Kg											460 J	
Nitro polyaromatic compound(23.91	µg/Kg										5300 J		
Octadecanoic acid (13.59)	µg/Kg		450										
Oxy hydrocarbon (4.23)	µg/Kg			330 J									
Oxy hydrocarbon (4.79)	µg/Kg				450 J								
Oxyhydrocarbon (5.76)	µg/Kg					230 J							
PNA (13.43)	µg/Kg							280 J					
PNA (23.04)	µg/Kg							310 J					
Poly aromatic compound (16.46)	µg/Kg				470 J								
Unknown Acid Ester (5.56)	µg/Kg				2000 J								
Unknown Acid Ester (5.96)	µg/Kg				4100 J								
Unknown Acid Ester (6.20)	µg/Kg				400 J								
Unknown Alkane (15.74)	µg/Kg								1500 J				
Unknown Alkane (15.80)	µg/Kg							270 J					
Unknown Alkane (15.84)	µg/Kg								1200 J				
Unknown Alkane (15.89)	µg/Kg							250 J					
Unknown Alkane (15.90)	µg/Kg								900 J				
Unknown Alkane (16.00)	µg/Kg							430 J					
Unknown Alkane (16.01)	µg/Kg								2900 J				
Unknown Alkane (16.08)	µg/Kg								1400 J				
Unknown Alkane (16.17)	µg/Kg								1200 J				
Unknown Alkane (16.30)	µg/Kg							460 J	2200 J				
Unknown Alkane (16.43)	µg/Kg							280 J					
Unknown Alkane (16.44)	µg/Kg								2100 J				
Unknown Alkane (16.67)	µg/Kg							640 J					
Unknown Alkane (16.68)	µg/Kg								890 J				
Unknown Alkane (17.89)	µg/Kg									210 J			
Unknown Ketone (4.22)	µg/Kg		190										
Unknown Ketone (4.23)	µg/Kg				230 J		160 J					210 J	
Unknown Ketone (4.24)	µg/Kg										260 J		
Unknown Oxyhydrocarbon (4.18)	µg/Kg									260 J			220 J
Unknown Oxyhydrocarbon (4.19)	µg/Kg							290 J					
Unknown Oxyhydrocarbon (4.98)	µg/Kg									230 J			
METALS													
Aluminum	mg/Kg	10000 J	11000 J	5700 J	20000 J	29000 J	5800 J	8400 J	13000 J	21000 J	22000 J	13000 J	29000 J
Antimony	mg/Kg	R	R	R	R	R	R	R	R	R	R	R	R
Arsenic	mg/Kg	6.9 U	9.2	8.8	20	37	6.9 U	6.9 U	6.9 U	6.9 U	26	20	47
Barium	mg/Kg	11 J	32 J	15 J	31 J	41 J	11 J	18 J	100 J	31 J	27 J	32 J	110 J
Beryllium	mg/Kg	0.032 U	0.16	0.032 U	0.21	0.32	0.068	0.25	0.16	0.11	0.14	0.092	0.34 U
Cadmium	mg/Kg	0.078 U	0.078 U	0.078 U	0.078 U	0.078 U	0.13	0.33	0.31	0.078 U	0.078 U	0.078 U	0.078 U

SUBSURFACE SOIL ANALYTICAL DATA
CAFB FUEL HYDRANT SS-41

COMPOUND	ID: DEPTH: DATE:	SB-01 04-06' 10/03/95	SB-01-DUP 06-08' 10/03/95	SB-02 06-08' 10/03/95	SB-03 04-06' 10/03/95	SB-04 04-06' 10/04/95	SB-05 04-06' 10/04/95	SB-06 04-06' 10/04/95	SB-07 04-06' 10/04/95	SB-08 04-06' 10/04/95	SB-09 06-08' 10/04/95	SB-10 04-06' 10/04/95	SB-11 06-08' 10/04/95
Calcium	mg/Kg	87	92	68	130	130	350	80000	4700	330	85	54	140
Chromium	mg/Kg	7.9 J	8.2 J	5.6 J	12 J	18 J	6.4 J	11 J	11 J	19 J	20 J	8.5 J	17 J
Cobalt	mg/Kg	0.68	1.9	0.42 U	1.6	1.8	0.71	2.1	3.8	2.1	1.9	0.79	1.8
Iron	mg/Kg	4100 J	2900 J	1100 J	5500 J	5500 J	2400 J	4300 J	16000 J	15000 J	7400 J	1900 J	3200 J
Lead	mg/Kg	11	5 J	4.5	13	23	4.3 J	20	11	8.3	9	6 J	13
Lithium	mg/Kg	5.7	3.5	1.6	3.7	8.1	2.5	5.1	7.7	12	11	4.6	13
Magnesium	mg/Kg	220 J	950 J	220 J	220 J	460 J	160 J	1100 J	400 J	370 J	410 J	270 J	520 J
Manganese	mg/Kg	13 J	30 J	8.6 J	9.6 J	15 J	8.4 J	50 J	14 J	15 J	15 J	5.5 J	10 J
Molybdenum	mg/Kg	1.1	0.82 U	0.82 U	0.82 U	1.2 U	0.82 U	0.82 U	2 U	2.2 U	1.1 U	0.82 U	0.82 U
Nickel	mg/Kg	2.1	4.1	3.4	2.3	4.1	1.8	5.9	4.9	2.2	3.5	2.4	6.1
Phosphorus	mg/Kg	4.1 U	4.1 U	11 U	4.1 U	4.1 U	99	500	550	4.1 U	4.1 U	4.1 U	4.1 U
Potassium	mg/Kg	240 J	1000 J	240 J	180 J	370 J	180 J	460 J	260 J	270 J	410 J	250 J	470 J
Selenium	mg/Kg	5 U	5 U	5 U	5 U	7	5 U	5 U	11	9.4	5 U	5 U	5 U
Sodium	mg/Kg	18 U	18 U	14 U	44	41	41	130	48	35 U	36	14 U	27 U
Strontium	mg/Kg	3	2.3	2.2	4.9	5	3.7	87	13	7.8	4.9	3.3	6.4
Vanadium	mg/Kg	11	8.9	5.1	18	27	8.6	12	15	22	33	8.3	15
Zinc	mg/Kg	9.6	11	10	6.6	11	5.4	13	19	8.1	11	9.6	18
OTHER													
TPH-JP4	mg/Kg	11 U	11 U	12 U	44 J	13 U	11 U	11 U	16	13 U	12 U	11 U	15 U
TKN	mg/Kg	87	46	340	260	370	160	200	470	49	96	33	110
Total Phosphorus	mg/Kg	35	21	91	62	53	61	120	190	33	45	18	50
Solids, Percent	%	87.6	91.1	80.3	81.5	78.7	89.2	89.7	85.2	78	81	90.4	65.5
pH	PH UNITS	4.9	5.8	5.2	4.6	4.3	4.9	6.8	8	4.8	5.3	6.1	5.1

U = Not detected.
J = Estimated value.
R = Unusable data.

APPENDIX C

1.1 INTRODUCTION

A risk evaluation was conducted for the Fuel Hydrant System (Site SS-41) located at Charleston Air Force Base, Charleston, SC. The purpose of this evaluation is to assess potential risks to human health and the environment resulting from exposure to on-site media.

The methodology used in this assessment include SCDHEC guidance for Risk-Based Corrective Action (RBCA) for Petroleum Releases (SCDHEC, 1995) for indicator chemicals associated with petroleum-related contamination and USEPA Region IV screening methodology (USEPA, 1995a) for those constituents not included in the RBCA guidance. The RBCA guidance focuses on the evaluation of potential risks to human health and the Region IV screening guidance focuses on the evaluation of potential risks to both human health and the environment.

The RBCA methodology describes a tiered evaluation that includes 3 distinct tiers, beginning with a conservative Tier 1 approach and progressing to a complex, site-specific Tier 3 approach. The steps involved in the RBCA assessment are presented in Figure 4.1 and those involved in the Region IV screening process are presented in Figure 4.2.

The following media are addressed in this risk evaluation: groundwater, subsurface soil, sediment and surface water. Surface soil data was not available for evaluation. Regardless of whether the RBCA or Region IV screening methodology was used to evaluate the contaminants at Site SS-41, the treatment of the data was identical. After combining analytical data and eliminating those analytes not detected in any samples in a particular medium, the analytical data were evaluated on the basis of quality, with respect to sample quantitation limits, laboratory qualifiers and codes, and blanks. Data selected for use in the evaluation included unqualified data and those data with qualifiers that indicated uncertainties in concentrations, but not in compound identification. Analytical data with an "R" (unreliable) qualifier were not selected for use in the evaluation. Also not selected were data with qualifiers indicating that the analyte was detected in a laboratory blank at a level below the 10-times or 5-times rule for organics (for common laboratory contaminants and other compounds, respectively) or below the 5-times rule for pesticides and inorganics (EPA, 1989).

1.2 RISK-BASED CORRECTIVE ACTION (RBCA) EVALUATION

1.2.1 Initial Site Assessment

A discussion of the site background, including the site description and site history, is presented in Section 1.0. This risk evaluation is limited to the assessment of samples taken in the vicinity of the existing and former fuel hydrant system pumping stations at Buildings 99, 95, and 93 on the east side of the flightline drainage ditch that parallels Taxiway #44 and the aircraft apron. Limited data were also available for those portions of the fuel hydrant system located on the west side of the drainage ditch due to ongoing Navy fuel hydrant system and aircraft apron renovation projects.

The primary source of contamination at the site is petroleum spills from the operation of the fuel hydrant system. The location of the maximum detected concentrations of contaminants in soil, groundwater, and surface water/sediment are discussed and presented in Section 3.0, Nature and Extent of Contamination. The maximum detected concentrations of contaminants in site media were located near the pumping stations. Section 3.0 discusses the chemicals present in site samples (CPSS) that were evaluated in the risk characterization.

Hydrogeological conditions at the site are discussed in Section 2.0. The overall direction of groundwater flow at the site is to the south. Shallow groundwater is expected to discharge to the flightline drainage ditch. Based on the groundwater flow velocity through the site, it is expected to take a minimum of 17 years for advective groundwater flow to reach the closest downgradient base boundary from Site SS-41 (distance of 4,800 ft).

The base obtains drinking water from the Charleston Commission of Public Works, with intakes located in major surface water bodies (Edisto River, Goose Creek Reservoir and Foster Creek). No domestic or industrial wells are known to be located in the surficial aquifer. The only known deep well in the vicinity of the site is maintained for limited private use and is located about three miles southwest of Charleston AFB. This well is 380 ft deep and supplies water for a heat pump and garden irrigation. Three deep wells used to pump groundwater for industrial use are also located in the vicinity of the base.

Currently, the site is located within a patrolled military installation. Trespassing onto the site is not likely given that the site is surrounded by a fence and is patrolled by military personnel. Current receptors, therefore, include on-site military personnel. In the future, the site will remain a military facility. Consequently, the only realistic receptors will be future military workers.

1.2.2 Site Priority Classification

The site is classified as a Class 5 priority, based on the current and projected degree of hazard to human health and the environment. A Class 5 designation indicates that there is no demonstrable threat to human health or the environment although CDSSs are expected to exceed Tier 1 Risk-Based Screening Levels (RBSLs) and further assessment is needed. Although the concentrations of CDSSs are relatively low, it was conservatively assumed that RBSLs would be exceeded and further assessment would be necessary.

1.2.3 Tier 1 Evaluation

The Tier 1 evaluation compares on-site concentrations to RBSLs provided in the RBCA guidance for indicator chemicals associated with petroleum contamination. Although TPH is included as an indicator chemical in the RBCA guidance, it cannot be quantitatively evaluated due to the lack of toxicity data. The RBSLs are based on conservative exposure scenarios.

1.2.3.1 Site Conceptual Model

The site conceptual model identifies all complete exposure pathways using information about site operations, sources, and releases (SCDHEC, 1995). Figure C.1 presents a schematic of the site conceptual model and Tables C.1 and C.2 present a matrix of the potential exposure pathways associated with current and future human receptors. Although ecological endpoints are not included in the RBCA process, potential ecological receptors are included in the conceptual site model to be used in the Region IV screening process (Section C.1).

The following potential receptors are identified for the Fuel Hydrant System:

Current and Hypothetical Future Off-Site Residents

Off-site residents are defined as those individuals that reside to the south of the site, over the Charleston AFB property boundary. These residents are currently supplied drinking water via the Charleston Commission of Public Works. Although highly unlikely, it is possible that future off-site residents will obtain their drinking water from a hypothetical private well located at the boundary of Charleston AFB. This well, however, would likely be located in the deep aquifer, which is not impacted by Site SS-41 contaminants, rather than the surficial aquifer. If a well were present in the surficial aquifer, however, contaminants resulting from Site SS-41 would not be present at significant concentrations, given the distance from the site to the installation boundary and the fact that it is estimated to take 17 years for site groundwater to reach the installation boundary under conditions of natural attenuation.

Given that the site is fenced and patrolled by the Air Force, and that the site is located on a flightline, it is highly unlikely that these nearby residents will trespass onto the site and become exposed to soil, surface water, and sediment. The only potential exposure of these receptors to site media is through the inhalation of volatiles and particulates from soil. Given the distance from the site to the residents, however, the concentration of contaminants that may reach the residents will be negligible. The off-site resident, therefore, is not expected to be impacted by contaminants in any on-site media now or in the future.

Current and Hypothetical Future Workers

Workers are defined as those individuals that are employed on-site and have unlimited access to media at the Fuel Hydrant System. Current and future workers will be exposed to surface soil as well as surface water and sediment located in the drainage ditch. In the future, workers will be exposed to surface soils comprised of a mixture of surface and subsurface soils, as a result of future excavation and redistribution of subsurface soils during future site development. Future workers are also assumed to obtain drinking water from on-site wells and, therefore, will be exposed to groundwater.

Hypothetical Future On-Site Residents

There are no current on-site residents. Given that the site is expected to remain a military installation in the future, and Site SS-41 is expected to remain in proximity to a flightline, future residential development of the site will not occur.

1.2.3.2 Data Requirements

Data requirements needed to assess petroleum-related contaminants using the RBCA guidelines (SCDHEC, 1995) for Tier 1 include:

- Maximum detected concentration of contaminants in groundwater, subsurface soil and sediment for comparison to RBSLs. To be conservative, sediment will be evaluated as surface soil. Surface soils were not available for evaluation.

- For the assessment of soil leaching to groundwater, the average concentration of the three highest detections in soil was used for comparison to RBSLs, where available.

1.2.3.3 Risk Evaluation

Tables C.3 through C.7 present the Tier 1 evaluation for groundwater (Table C.3), subsurface soil (Tables C.4 and C.5), and sediment (Tables C.6 and C.7). For subsurface soils and sediment, separate evaluations were completed to assess direct contact with contaminants in these media and the potential impacts of contaminants leaching from soil to groundwater. For direct contact, RBSLs were available for both residential and industrial. Per RBCA guidance, the comparison was completed using the more conservative, residential value, although the industrial value is more applicable to site conditions.

For groundwater (Table C.3), the maximum detected concentration of benzene (86 ug/L) exceeded the RBSL (5 ug/L). No other VOC nor SVOC exceeded the RBSL.

For direct contact with subsurface soil (ingestion or dermal contact), the maximum detected concentration of benzo(b)fluoranthene (1.4 mg/kg) exceeded the RBSL (0.88 mg/kg for residential exposure). For the assessment of soil leaching to groundwater, the maximum concentrations of benzo(a)anthracene (0.79 mg/kg), benzo(b)fluoranthrene (1.4 mg/kg), and chrysene (1 mg/kg) exceeded RBSLs. Given that fewer than three detections were reported for any of these contaminants, the recommended screening against the mean of the top three detections was not possible and the RBSL was compared to the maximum detected concentration.

Sediments were evaluated as surface soils, which is a conservative assumption given that sediments are expected to be covered by surface water and will not be as readily available for exposure as soils. For direct contact (ingestion or dermal contact), the maximum detected concentration of benzo(b)fluoranthene (1.04 mg/kg) exceeded the RBSL (0.88 mg/kg). For the assessment of soil leaching to groundwater, the maximum detected concentrations of benzo(b)fluoranthene (1.04 mg/kg) and chrysene (0.84 mg/kg) exceeded RBSLs.

1.2.4 Tier 1 Action

There are four possible actions resulting from the Tier 1 evaluation:

1. **No Further Action**, when concentrations of contaminants are below RBSLs.

2. **Interim Remedial Action**, when concentrations of contaminants exceed RBSLs and partial source removal or other actions may be necessary to reduce the risk. Free-product must be removed to the extent practicable.

3. **Further Tier Evaluation**, when the concentrations of contaminants exceed RBSLs, further evaluation is warranted under the following conditions:

- If site-specific target levels (SSTLs) developed in Tier 2 using site-specific information will be significantly different than the RBSLs.

- If the cost of remedial action to the RBSL will likely be greater than further tier evaluation.

- If the approach or assumptions used to derive the RBSLs are not appropriate for conditions at the site.

4. **Corrective Action**, when the concentrations of contaminants exceed RBSLs and interim remedial actions or further tiered evaluation are not appropriate, a corrective action plan (CAP) should be submitted.

The results of the Tier 1 evaluation reported that benzene in groundwater and several PAHs in subsurface soil and sediment exceeded RBSLs, indicating that No Further Action is not a reasonable Tier 1 Action. Given that few exceedances were reported, and that the exceedances were within an order of magnitude of the RBSL, neither an Interim Remedial Action nor a Corrective Action Plan are appropriate at Site SS-41.

At the Site SS-41 site, option 3 is the most appropriate. Given that the reasonably anticipated future use of the site is military, the residential scenarios used to establish the RBSLs are not appropriate. Further Tier 2 evaluation using an industrial exposure scenario will be used to allow for a more realistic assessment of contaminants at Site SS-41.

1.2.5 Tier 2 Assessment

Given that the RBSLs used in the Tier 1 assessment were based on a residential exposure scenario, they are not applicable to the Fuel Hydrant System. The Tier 2 assessment will focus on the derivation of SSTLs that reflect the current and future industrial use of the site. Additional data needed to complete the soil to groundwater leachability modeling in Tier 2 included on-site TPH, background total organic content and the distance from the highest detected concentration to groundwater.

1.2.6 Tier 2 Evaluation

1.2.6.1 Establish the SSTLs

SSTLs were derived for the ingestion of groundwater by workers. For soils, SSTLs were derived to address potential direct contact to soils as well as potential leachability of contaminants from soil to groundwater.

Groundwater

SSTLs for groundwater were established to assess the ingestion of groundwater by hypothetical future workers. Although it is highly unlikely that future workers will obtain their drinking water from wells located in the surficial aquifer, SSTLs were established for these receptors. The SSTLs were based on the ingestion of 1L/day of water for 250 days/year over a period of 25 years by workers.

Table C.3 presents the results of the Tier 2 screening. Benzene (maximum concentration of 86 ug/L), which exceeded the Tier 1 screening, also exceeded the Tier 2 screening. No other petroleum-related contaminants exceeded the Tier 1 or Tier 2 screening. Although benzene did exceed the Tier 2 screening, the likelihood of any worker being exposed to the groundwater in the future is extremely unlikely.

Soil

SSTLs for direct contact with soil/sediment were obtained from the Region IX Preliminary Remediation Goal (PRG) guidance (USEPA, 1995b). Per SCDHEC (1995) guidance, Tier 2 SSTLs should include potential exposure via ingestion, inhalation and dermal contact. The published Region IX PRGs include these pathways in the derivation of PRGs for industrial receptors. Tables C.4 and C.6 present the Tier 2 comparison for subsurface soils and sediment, respectively. There were no exceedances of Tier 2 SSTLs for either media.

SSTLs for soil to groundwater leachability were derived using SCDHEC guidance (1995). Tables C.8 through C.11 document the site-specific factors and assumptions used in the derivation of the SSTLs. Table C.8 presents the site-specific factors and Table C.9 presents the chemical-specific information used in the leachability model. The results of the model for subsurface soil and sediment are provided in Tables C.10 and C.11, respectively.

Tables C.5 and C.6 present the Tier 2 screening of the soil leaching to groundwater. There were no exceedances of Tier 2 SSTLs for either subsurface soil or sediment.

1.2.6.2 Establish Points of Compliance

The assumed point of compliance for the groundwater is on-site. It is assumed that a future worker will be exposed to groundwater in the surficial aquifer. This is an extremely conservative assumption, however, given that the site is anticipated to continue to obtain its water via a municipal supply and that, if drinking water wells were to be placed on-site, they would be placed in the deep aquifer and not the surficial aquifer.

The assumed point of compliance for subsurface soils and sediment is on-site.

1.2.6.3 Tier 2 Action

There are four possible actions resulting from the Tier 2 evaluation:

1. **Verification Monitoring/Intrinsic Remediation**, when concentrations of contaminants are below SSTLs and further contaminant delineation is not necessary. A CAP proposing a short-term monitoring program to verify intrinsic remediation should be submitted.

2. **Interim Remedial Action**, when concentrations of contaminants exceed SSTLs and partial source removal or other actions may be necessary to reduce the risk. Free-product must be removed to the extent practicable.

3. **Further Tier Evaluation**, when the concentrations of contaminants exceed SSTLs, but further evaluation is warranted under the following conditions:

- If site-specific target levels (SSTLs) developed in further tier evaluation using site-specific information will be significantly different than the Tier 2 SSTLs.

- If the cost of remedial action to the SSTL will likely be greater than further tier evaluation.

- If the approach or assumptions used to derive the SSTLs are not appropriate for conditions at the site.

4. **Corrective Action**, when the concentrations of contaminants exceed SSTLs and interim remedial actions or further tiered evaluation are not appropriate, a corrective action plan (CAP) should be submitted.

The results of the Tier 2 evaluation reported that benzene in groundwater exceeded the SSTL, indicating that Verification Monitoring/Intrinsic Remediation is not a reasonable Tier 2 Action for groundwater. For subsurface soil and sediment, however, no contaminants exceeded the Tier 2 SSTL, indicating that no adverse effects on human health are expected in receptors exposed to these media. Further evaluation of these media are not warranted. Given that only one (benzene in groundwater) exceedance was reported, and that the exceedance was within an order of magnitude, neither an Interim Remedial Action nor a Corrective Action Plan are appropriate at Site SS-41.

At Site SS-41, no further analysis of subsurface soil and sediment is recommended given that maximum concentrations of contaminants in these media did not exceed Tier 2 SSTLs.

For groundwater, given the exceedance of benzene, option 3 is the most appropriate action. The assumed point of compliance for the groundwater is on-site. It is assumed that a future worker will be exposed to groundwater in the surficial aquifer. This is an extremely conservative assumption, however, given that the site is anticipated to continue to obtain its water via a municipal supply and that, if drinking water wells were to be placed on-site, they would be placed in the deep aquifer and not the surficial aquifer. The more realistic point of compliance for groundwater is the property boundary where it is possible that future off-site residents may be exposed to groundwater via a private well, although a private well is more likely to be located in the deep aquifer instead of the surficial aquifer. A Tier 3 analysis will evaluate this point of compliance using groundwater modeling results discussed in Section 5.

1.2.7 Tier 3 Evaluation

For groundwater, given the exceedance of benzene, Tier 3 analysis is appropriate. Using the groundwater modeling results discussed in Section 5, an evaluation of concentrations of benzene present at the point of compliance (property boundary) was performed. In Tier 2, the assumed point of compliance was on-site. This assumption is highly conservative given that the site is anticipated to continue to obtain its water via a municipal supply and that, if drinking water wells were to be placed on-site, they would be placed in the deep aquifer and not the surficial aquifer. The more realistic point of compliance for groundwater is the property boundary where it is possible that future off-site residents may be exposed to groundwater via a private well.

Table C.12 compares the results of the groundwater modeling at the property boundary to the Tier 1 RBSL, which evaluates potential residential exposure because it is more likely that a resident would be exposed at the property boundary than a worker. The Tier 1 RBSL, therefore, becomes the Tier 3 SSTL for benzene. The concentration of benzene at the installation boundary does not exceed the SSTL for any of the pumping stations.

1.2.7.1 Tier 3 Action

There are two potential action outcomes from the Tier 3 analysis:

1. **Verification Monitoring/Intrinsic Remediation**, when the concentrations of contaminants are below the SSTL and further contaminant delineation is not necessary, a CAP proposing a short-term monitoring program to verify intrinsic remediation should be submitted.

2. **Corrective Action**, when the concentrations of contaminants are above the SSTL, a CAP for active cleanup and/or intrinsic remediation should be submitted.

Given that the modeled concentration of benzene in groundwater did not exceed the Tier 3 SSTL, verification monitoring/intrinsic remediation is recommended for groundwater.

1.3 REGION IV SCREENING

For those contaminants detected in Site SS-41 media, but not covered by the RBCA program, a site-specific screening was performed using Region IV screening methodology (USEPA, 1995a). The screening includes endpoints for the protection of both human health and the environment.

Chemicals present in site samples (CPSSs) were compiled for each media of concern and are presented in Table C.13 through C.17. Subsurface soils were evaluated to account for potential excavation and redistribution of soils during hypothetical future development of the site. Surface soils were not available for evaluation.

For the human health evaluation, CPSSs in groundwater, subsurface soils and sediment were screened against background concentrations, risk-based concentrations, nutrient essentiality, and frequency of detection (Tables C.13 through C.16) to determine chemicals of potential concern (COPCs). Per USEPA Region IV guidance, sediments were evaluated as soils for the human health screening process. Therefore, sediments were compared to background surface soil concentrations. This is a conservative approach because the sediments are covered with surface water and will not be available for exposure as readily as surface soils. Given that background concentrations and human health risk-based concentrations were not available for surface water, a human health screening was not performed for this medium.

Both surface water and sediment were screened against ecological endpoints. These results are shown in Tables C.15 (sediment) and C.17 (surface water). Ecological screening for subsurface soils was not appropriate given that terrestrial receptors are expected to be exposed to surface soils only.

The screening hierarchy was as follows:

1. Comparison of maximum on-site concentrations to Region III Risk-Based Concentrations (RBCs) for human health and comparison to Region IV Sediment and Surface Water Screening Criteria for ecological. For the human health analysis, a comparison to both residential and industrial receptors was completed. RBCs for industrial workers were used to provide a more realistic evaluation of site impacts, although residential values were provided for comparison.

For surface water, the maximum concentration of each detected analyte was compared to *Region IV Freshwater Surface Water Screening Values for Hazardous Waste Sites* (EPA, 1995a). These values generally represent federal chronic ambient water quality criteria (AWQC) values for protection of aquatic life. The AWQC for lead is based on hardness of the water; in the absence of unit-specific hardness data, a default hardness value of 50 mg/L as $CaCO_3$ was used to determine the lead criterion.

For sediment, the maximum concentration of each detected analyte was compared to *Region IV Sediment Screening Values for Hazardous Waste Sites* (EPA, 1995a).

1. Comparison of maximum on-site concentrations to site-specific background concentrations for subsurface soil, sediment and groundwater. Inorganic contaminants were considered indicative of background concentrations and were eliminated from further analysis if they were present at less than twice the mean background concentration. Organic contaminants were assumed to be site-related and were not eliminated using the background screen.

2. Analysis of the frequency of detection: if a contaminant was detected in less than 5% of on-site samples, it was eliminated for further consideration as a COPC (minimum of 20 samples needed for this analysis).

In addition, those inorganics considered essential nutrients were eliminated from further consideration (i.e., calcium, sodium) because they are toxic only at extremely high concentrations.

Human nutrient essentiality was evaluated for both soil/sediment and groundwater for those inorganics that exceeded both the background and human health risk-based concentration screening. The following inorganic compounds were evaluated using the essentiality screen: calcium, chloride, iodine, magnesium, phosphorus, potassium and sodium. To determine if essential inorganics should be eliminated as COPCs, the maximum concentrations in media were adjusted to reflect daily intake and compared to the recommended daily allowance (RDA) or Safe and Adequate Daily Intake (SADI) (NAS, 1989). For soil/sediment, the maximum soil concentration was multiplied by an ingestion rate of 200 mg/day for a residential child (EPA, 1991). For groundwater, the maximum water concentration was multiplied by the ingestion rate of 2 L/d for a resident (EPA, 1991). If the estimated dose was below the RDA/SADI, the essential nutrient was eliminated as a COPC.

1.4 SUMMARY AND CONCLUSIONS

1.4.1 Summary

A risk evaluation was conducted for the Fuel Hydrant System (Site SS-41) located at Charleston Air Force Base, Charleston, SC. The purpose of this evaluation was to assess potential risks to human health and the environment resulting from exposure to on-site media.

The methodology used in this assessment include SCDHEC guidance for Risk-Based Corrective Action (RBCA) for Petroleum Releases (SCDHEC, 1995) for indicator chemicals associated with petroleum-related contamination and USEPA Region IV screening methodology (USEPA, 1995a) for those constituents not included in the RBCA guidance. The RBCA guidance focuses on the evaluation of potential risks to human health and the Region IV screening guidance focuses on the evaluation of potential risks to both human health and the environment.

The results of the RBCA and Region IV screening process are discussed by media in the following sections.

1.4.1.1 Groundwater

Groundwater was assessed for potential impacts to human health only, ecological receptors at the site are not expected to be impacted by surficial groundwater. Although surficial groundwater is expected to discharge to surface water located in the flightline drainage ditch, the surface water and sediment in the drainage ditch were evaluated for ecological impacts.

A Tier 3 RBCA screening was completed for groundwater at Site SS-41. No contaminants were identified following the screening process, resulting in a recommended RBCA action of short-term monitoring to verify intrinsic remediation.

For those contaminants not included in the RBCA process, several metals were present that exceeded both RBCs and a background screen. The elevated concentrations of these metals in groundwater, however, may have resulted from sampling techniques that allowed inclusion of sediments with the groundwater sample. One organic contaminant (p-isopropyltoluene) was not evaluated because an RBC was not available. Given that this organic is not a known contaminant at Site SS-41 and that the frequency of detection was very low (1/14), non-inclusion of this contaminant in the evaluation should not result in should not significantly effect the results.

1.4.1.2 Subsurface Soil

Subsurface soil was assessed for potential exposure of future on-site industrial workers. Future industrial development of the site is expected to result in excavation and redistribution of subsurface soils onto the site, resulting in potential exposure of future receptors to subsurface soils. Subsurface soils were not addressed for ecological receptors.

A Tier 2 RBCA screening was completed for subsurface soils. The screening included an evaluation of potential direct contact (ingestion or dermal contact) as well as potential

leachability of contaminants from soil to groundwater. Neither scenario resulted in an exceedance of Tier 2 screening criteria.

For those chemicals not included in the RBCA process, benzo(a)pyrene and arsenic exceeded both the industrial RBC and/or background. Benzo(a)pyrene, however, was detected in only one out of twelve samples and the RBCA evaluation determined that the indicator PAHs did not result in adverse effects on humans. Therefore, the exceedance of benzo(a)pyrene in the Region IV screening process (maximum detected of 0.85 mg/kg vs. Industrial SSTL of 0.78 mg/kg) is not considered to be significant. Arsenic is not a known contaminant at the site and the source of the elevated arsenic concentration in subsurface soils is not known.

Two organic contaminants (p-isopropyltoluene and n-propylbenzene) were not evaluated because RBCs were not available. Given that these organics are not known contaminants at Site SS-41 and that the frequency of detection was very low (1-2/14), non-inclusion of these contaminants in the evaluation should not result in should not significantly effect the results. Additionally, RBCs were not available to evaluate benzo(ghi)perylene and phenanthrene. The RBCA process, however, evaluated indicator PAHs which did not exceed SSTLs. Consequently, it is assumed that because the indicator PAHs did not exceed SSTLs, the site should be acceptable for all PAHs.

1.4.1.3 Surface Water

Surface water was not addressed using the RBCA guidance, but was addressed using the Region IV screening process. Surface water was addressed for potential impacts to both human health and the environment.

For human health, exceedances were found for several PAHs, bis(2-ethylhexyl)phthalate, iron and manganese. The screening criteria evaluated, however, reflected ingestion of surface water as well as organisms, such as fish. Given that the surface water is located in a drainage ditch on the side of a flightline, exposure of humans to surface water and organisms within the ditch is highly unlikely.

Region IV ecological screening values were available for only nine chemicals detected in surface water at Site SS-41. Maximum detected concentrations of bis(2-ethylhexyl)phthalate, aluminum, copper, and iron exceeded chronic screening values). Copper and bis(2-ethylhexyl)phthalate, however, were detected in only one sample. Several additional chemicals were also retained as COPCs due to the lack of screening values. However, many of these chemicals were also detected in only one sample with the exception of the metals and TPH. Due to the low frequency of detection of many of the COPCs and the low habitat values of the Site SS-41 area, the exposure of ecological receptors to COPCs in surface water resulting in significant effects is unlikely.

1.4.1.4 Sediment

Sediment was addressed for potential impacts to both human health and the environment. For human health, sediment was addressed in both the RBCA and Region IV screening processes as surface soil. This is a conservative assumption given that the sediment in the ditch is expected to be covered with surface water, rendering it unavailable for ingestion by future workers.

A Tier 2 RBCA screening was completed for sediment. The screening included an evaluation of potential direct contact (ingestion or dermal contact) as well as potential leachability of contaminants from soil to groundwater. Neither scenario resulted in an exceedance of Tier 2 screening criteria.

For those chemicals not included in the RBCA process, arsenic exceeded both the industrial RBC and background. Arsenic is not a known contaminant at the site and the source of the elevated arsenic concentration in subsurface soils is not known. Although RBCs were not available to evaluate benzo(ghi)perylene and phenanthrene, the RBCA process evaluated indicator PAHs. It is assumed that because the indicator PAHs did not exceed SSTLs, the site should be acceptable for all PAHs.

Region IV ecological screening values were available for only twelve chemicals detected in sediments at Site SS-41. Maximum detected concentrations of several PAHs and arsenic exceed screening values). Arsenic, however, was detected in only one sample. Inorganic chemical concentrations were also compared to two times the mean surface soil background concentration. Several additional chemicals (VOCs, PAHs, TPH, and metals) were retained as COPCs due to the lack of Region IV screening values or because they exceeded background. All VOCs were detected in only one sample with the exception of trichloroethene. The exposure of ecological receptors to COPCs in sediment resulting in significant effects, however, is unlikely due to the low habitat values of the Site SS-41 area.

Figure C-1. Conceptual Site Model for the Fuel Hydrant System - Charleston AFB

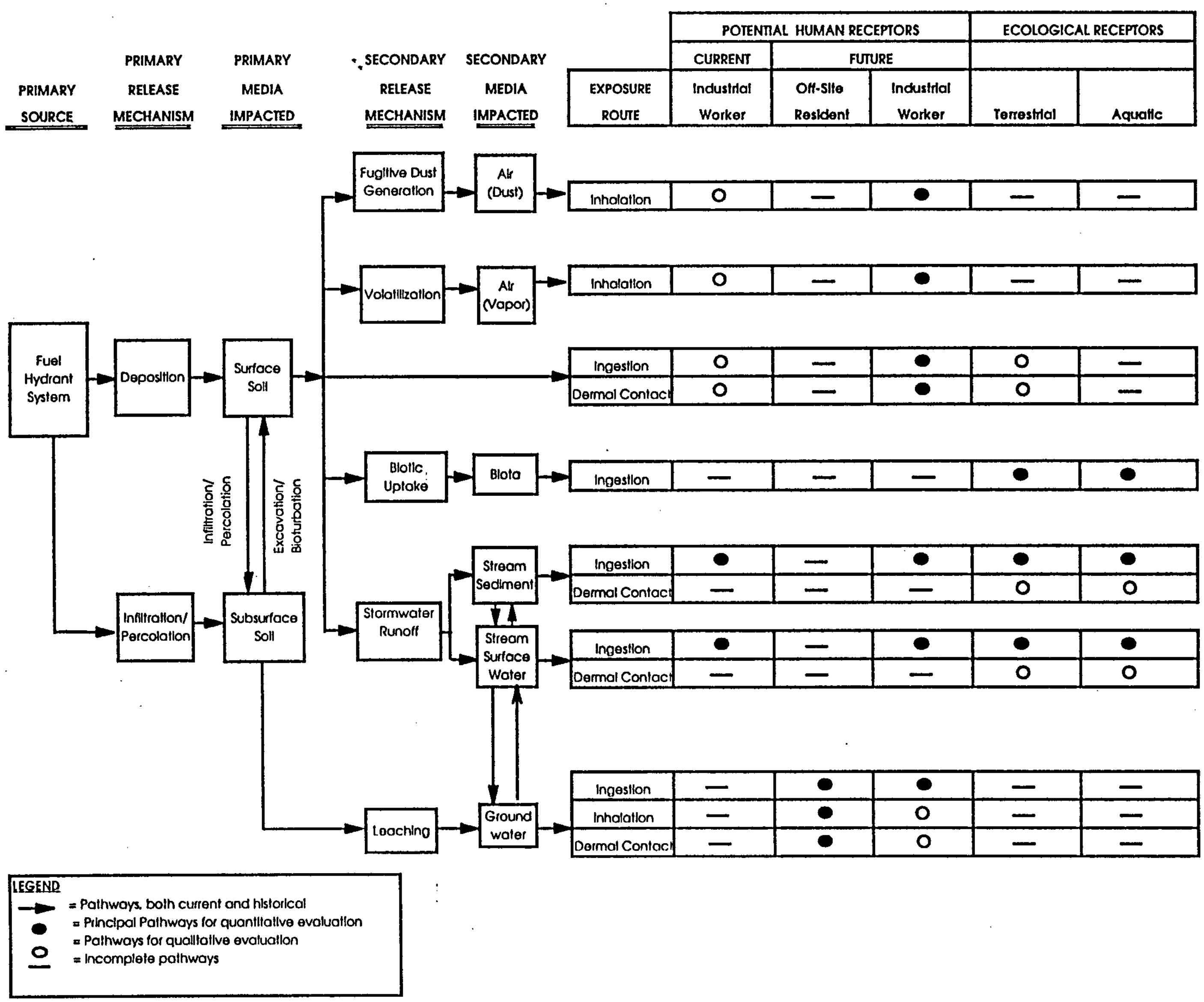

TABLE C.1
MATRIX OF POTENTIAL
EXPOSURE PATHWAYS
FUEL HYDRANT SYSTEM, CHARLESTON AFB
CHARLESTON, SOUTH CAROLINA

CURRENT RECEPTORS

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Offsite resident	Ingestion of groundwater at tap	No	No drinking water wells in area
	Inhalation of volatiles released during showering	No	No drinking water wells in area
	Dermal contact with groundwater during showering	No	No drinking water wells in area
	Direct contact with surface soil	No	Offsite soil has not been impacted by the site.
	Inhalation of soil volatiles and particulates	No	The site is at a distance from the nearest off-site receptor. Any exposure to volatiles or particulates from soil will be negligible.
Onsite resident	All media and exposure pathways	No	There are no onsite residents
Worker	Ingestion of groundwater at tap	No	There are no supply wells in the vicinity
	Inhalation of volatiles released from groundwater while showering	No	Not applicable since showering will not be done at the workplace.
	Dermal contact with groundwater while showering	No	Not applicable since showering will not be done at the workplace.

Direct contact with surface soil	Yes	Current workers may contact surface soil at the site, but surface soil is not available for evaluation.
Inhalation of soil volatiles and particulates	Yes	Current workers may be exposed to volatiles and particulates from soil at the site, but surface soil is not available.
Direct contact with surface water and sediment	Yes	Current workers may be exposed to surface water and sediment in on-site ditch.

TABLE C.2
MATRIX OF POTENTIAL EXPOSURE PATHWAYS
FUEL HYDRANT SYSTEM, CHARLESTON AFB
CHARLESTON, SOUTH CAROLINA

FUTURE RECEPTORS

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Offsite resident	Ingestion of groundwater at tap	Yes	No drinking water wells in area, but it is possible that off-site wells will be used in the future
	Inhalation of volatiles released during showering	Yes	No drinking water wells in area, but it is possible that off-site wells will be used in the future
	Dermal contact with groundwater during showering	Yes	No drinking water wells in area, but it is possible that off-site wells will be used in the future
	Direct contact with surface soil	No	Offsite soil has not been impacted by the site.
	Inhalation of soil volatiles and particulates	No	The site is at a distance from the nearest off-site receptor. Any exposure to volatiles or particulates from soil will be negligible.
Onsite resident	All media and exposure pathways	No	The site is currently military and is expected to remain military in the future. Therefore, there will be no onsite residents.
Worker	Ingestion of groundwater at tap	Yes	Although it is likely that the site will

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
			continue to be supplied via a municipal source, it is assumed that future workers will obtain water from on-site wells.
	Inhalation of volatiles released from groundwater while showering	No	Not applicable since showering will not be done at the workplace.
	Dermal contact with groundwater while showering	No	Not applicable since showering will not be done at the workplace.
	Direct contact with soil	Yes	Workers may contact soil at the site.
	Inhalation of soil volatiles and particulates	Yes	Workers may be exposed to volatiles and particulates from soil at the site.
	Direct contact with surface water and sediment	Yes	Future workers may be exposed to surface water and sediment in on-site ditch.

Table C.3
Charleston AFB
Fuel Hydrant Site
RBCA Tier 1: Comparison of Detected Concentrations to RBSLs - Groundwater

Chemical	CAS No.	Frequency of Detection	Maximum Detection (μg/l)	RBSL - Tier 1 (μg/l)[1]	Max Detect Exceeds RBSL?	SSTL - Tier 2 (μg/l)[2]	Max Detect Exceeds SSTL?
Benzene	71-43-2	6 / 28	8.60E+01	5.00E+00	Y	9.87E+00	Y
Ethylbenzene	100-41-4	4 / 28	2.50E+01	7.00E+02	N	1.02E+03	N
Toluene	108-88-3	5 / 28	8.40E+01	1.00E+03	N	2.04E+03	N
m,p-Xylene		3 / 28	9.80E+01	--	--	--	--
o-Xylene		2 / 28	9.00E+01	--	--	--	--
Xylenes, total[3]		5 / 56	1.88E+02	1.00E+04	N	2.04E+04	N
Naphathalene	91-20-3	2 / 14	2.30E+00	2.50E+01	N	4.09E+02	N
TPH							
TPH-JP4		4 / 8	4.80E+03	--	--	--	--

Notes:
1. Risk-based screening level (RBSL) from Look-up Table 4, SCDHEC, RBCA for Petroleum Releases, 6/95.
2. The Tier 2 SSTL was based on the following exposure scenario: ingestion of 1L/day of groundwater by a a future industrial worker (250 days/year for 25 years).
3. An RBSL was available for total xylenes only, therefore, the maximum concentrations of o-xylene and m,p-xylene were summed for comparison to the RBSL.

"--" not applicable: single detection or no RBSL.

Table C.4
Charleston AFB
Fuel Hydrant Site
RBCA Tier 1: Comparison of Maximum Detected Concentrations to RBSLs - Subsurface Soil

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	RBSL - Tier 1 (mg/kg)[1] Ingestion or Dermal Contact: Residential	RBSL - Tier 1 (mg/kg)[1] Ingestion or Dermal Contact: Industrial	Minimum RBSL (mg/kg)	Max of Detects Exceeds Minimum RBSL?	SSTL - Tier 2 (mg/kg)[2]	Max of Detects Exceeds SSTL?
Volatiles									
Benzene	71-43-2	1 / 12	1.70E-03	2.20E+01	9.90E+01	2.20E+01	N	3.15E+00	N
Ethylbenzene	100-41-4	1 / 12	1.70E-02	7.80E+03	1.00E+05	7.80E+03	N	1.34E+04	N
Toluene	108-88-3	1 / 12	2.70E-03	1.60E+04	2.00E+05	1.60E+04	N	6.94E+03	N
m,p-Xylene		1 / 12	1.10E-01	--	--	--	--	--	--[4]
o-Xylene		1 / 12	5.60E-02	--	--	--	--	--	--[4]
Xylenes, total[3]		2 / 24	1.66E-01	1.60E+05	1.00E+06	1.60E+05	N	4.64E+04	N
Semivolatiles									
Benzo(a)anthracene	56-55-3	1 / 12	7.90E-01	8.80E-01	3.90E+00	8.80E-01	N	2.61E+00	N
Benzo(b)fluoranthene	205-99-2	2 / 12	1.40E+00	8.80E-01	3.90E+00	8.80E-01	Y	2.61E+00	N
Benzo(k)fluoranthene	207-08-9	1 / 12	5.00E-01	8.80E+00	3.90E+01	8.80E+00	N	2.61E+01	N
Chrysene	218-01-9	1 / 12	1.00E+00	8.80E+01	3.90E+02	8.80E+01	N	2.61E+02	N
Naphathalene	91-20-3	2 / 12	2.50E-02	3.10E+03	4.10E+04	3.10E+03	N	9.50E+03	N
TPH									--
TPH-JP4		2 / 12	4.40E+01	--	--	--	--	--	--

Notes:
1. Risk-based screening level (RBSL) from Look-up Table 5 (sandy soil), SCDHEC RBCA for Petroleum Releases, 6/95.
2. The Tier 2 Site Specific Target Levels (SSTLs) were based on Preliminary Remediation Goals (PRGs) derived by Region IV (USEPA, 1995b). The SSTLs reflect exposure of industrial workers to soil via ingestion, inhalation and dermal contact.
3. An RBSL was available for total xylenes only, therefore, the maximum concentrations of o-xylene and m,p-xylene were summed for comparison to the RBSL.

"--" not applicable: single detection or no RBSL.

Table C.5
Charleston AFB
Fuel Hydrant Site
RBCA Tier 1: Comparison of Detected Concentrations to RBSLs - Leaching of Subsurface Soil to Groundwater

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	Mean of Top Three Detects[1] (mg/kg)	RBSL (mg/kg)[2] Leachability-Based	Mean of Detects Exceeds Minimum RBSL?[3]	SSTL (mg/kg)[4] Leachability-Based	Mean of Detects Exceeds Minimum SSTL?[3]
Volatiles								
Benzene	71-43-2	1 / 12	1.70E-03	--	7.00E-03	N	1.93E-02	N
Ethylbenzene	100-41-4	1 / 12	1.70E-02	--	1.70E+00	N	4.70E+00	N
Toluene	108-88-3	1 / 12	2.70E-03	--	1.70E+00	N	4.65E+00	N
m,p-Xylene		1 / 12	1.10E-01	--	--	--	--	--
o-Xylene		1 / 12	5.60E-02	--	--	--	--	--
Xylenes, total[5]		2 / 24	1.66E-01	--	4.40E+01	N	1.22E+02	N
Semivolatiles								
Benzo(a)anthracene	56-55-3	1 / 12	7.90E-01	--	7.00E-01	Y	7.70E+00	N
Benzo(b)fluoranthene	205-99-2	2 / 12	1.40E+00	7.85E-01	6.60E-01	Y	3.33E+00	N
Benzo(k)fluoranthene	207-08-9	1 / 12	5.00E-01	--	4.60E+00	N	5.09E+01	N
Chrysene	218-01-9	1 / 12	1.00E+00	--	6.60E-01	Y	2.13E+00	N
Naphathalene	91-20-3	2 / 12	2.50E-02	1.29E-02	2.00E-01	N	5.56E-01	N
TPH								--
TPH-JP4		2 / 12	4.40E+01	--	--	--	--	--

Notes:
1. Per SCDHEC (1995) guidance, the mean of the three highest detects was used as a comparison for RBSLs assessing soil to groundwater leaching.
2. Risk-based screening level (RBSL) from Look-up Table 5 (sandy soil) (SCDHEC, 1995).
3. If three detects were not available for derivation of a mean, the maximum detected value was used in the comparison.
4. The Site-Specific Target Levels (SSTLs) were derived using the methodology in SCDHEC (1995).
5. An RBSL was available for total xylenes only, therefore, the maximum concentrations of o-xylene and m,p-xylene were summed for comparison to the RBSL.

"--" not applicable: single detection or no RBSL.

Table C.6
Charleston AFB
Fuel Hydrant Site
RBCA Tier 1: Comparison of Maximum Detected Concentrations to RBSLs - Sediment

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	RBSL - Tier 1 (mg/kg)[1] Ingestion or Dermal Contact Residential	Commercial	Minimum RBSL (mg/kg)	Max of Detects Exceeds Minimum RBSL?	SSTL - Tier 2 (mg/kg)[2]	Max of Detects Exceeds SSTL?
Volatiles									
Toluene	108-88-3	1 / 7	3.00E-04	1.60E+04	2.00E+05	1.60E+04	N	6.94E+03	N
m,p-Xylene (RBSL for total)[3]		1 / 7	4.00E-04	1.60E+05	1.00E+06	1.60E+05	N	4.64E+04	N
Semivolatiles									
Benzo(a)anthracene	56-55-3	4 / 7	7.00E-01	8.80E-01	3.90E+00	8.80E-01	N	2.61E+00	N
Benzo(b)fluoranthene	205-99-2	5 / 7	1.04E+00	8.80E-01	3.90E+00	8.80E-01	Y	2.61E+00	N
Benzo(k)fluoranthene	207-08-9	2 / 7	3.60E-01	8.80E+00	3.90E+01	8.80E+00	N	2.61E+01	N
Chrysene	218-01-9	5 / 7	8.40E-01	8.80E+01	3.90E+02	8.80E+01	N	2.61E+02	N
TPH									
TPH-JP4		6 / 7	2.00E+01	--	--	--	N	--	--

Notes:
1. Risk-based screening level (RBSL) from Look-up Table 5 (sandy soil), SCDHEC RBCA for Petroleum Releases, 6/95.
2. The Tier 2 Site Specific Target Levels (SSTLs) were based on Preliminary Remediation Goals (PRGs) derived by Region IV (USEPA, 1995b).
The SSTLs reflect exposure of industrial workers to soil via ingestion, inhalation and dermal contact.
3. An RBSL was available for total xylenes only, therefore, the maximum concentration of m,p-xylene was used for comparison to the RBSL.
"--" not applicable: single detection or no RBSL.

Table C.7
Charleston AFB
Fuel Hydrant Site
RBCA Tier 1: Comparison of Detected Concentrations to RBSLs - Leaching of Sediment to Groundwater

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	Mean of Top 3 Detects[1] (mg/kg)	RBSL (mg/kg)[2] Leachability-Based	Max or Mean of Detects Exceeds Minimum RBSL?[3]	SSTL (mg/kg)[4] Leachability-Based	Max or Mean of Detects Exceeds Minimum RBSL?[3]
Volatiles								
Toluene	108-88-3	1 / 7	3.00E-04	--	1.70E+00	N	1.48E+01	N
m,p-Xylene (RBSL for total)[5]		1 / 7	4.00E-04	--	4.40E+01	N	3.83E+02	N
Semivolatiles								
Benzo(a)anthracene	56-55-3	4 / 7	7.00E-01	5.67E-01	7.00E-01	N	6.56E+00	N
Benzo(b)fluoranthene	205-99-2	5 / 7	1.04E+00	9.50E-01	6.60E-01	Y	5.93E+00	N
Benzo(k)fluoranthene	207-08-9	2 / 7	3.60E-01	3.10E-01	4.60E+00	N	4.31E+01	N
Chrysene	218-01-9	5 / 7	8.40E-01	7.67E-01	6.60E-01	Y	5.80E+00	N
TPH								
TPH-JP4		6 / 7	2.00E+01	--	--	--	--	--

Notes:
1. Per SCDHEC (1995) guidance, the mean of the three highest detects was used as a comparison for RBSLs assessing soil to groundwater leaching.
2. Risk-based screening level (RBSL) from Look-up Table 5 (sandy soil) (SCDHEC, 1995).
3. If three detects were not available for derivation of a mean, the maximum detected value was used in the comparison.
4. The Site-Specific Target Levels (SSTLs) were derived using the methodology in SCDHEC (1995).
5. An RBSL was available for total xylenes only, therefore, the maximum concentrations of o-xylene and m,p-xylene were summed for comparison to the RBSL.

"--" not applicable: single detection or no RBSL.

TABLE G.8

CHARLESTON AFB: FUEL HYDRANT SYSTEM
SOIL TO GROUNDWATER LEACHABILITY MODEL
Site-Specific Factors Used in the Leachability Model

Factor	Value	Units	Definition
Soil - % Sand	70	%	
Soil - % Clay	5	%	
Soil - % Silt	25	%	
foc - sediment	13418	mg/kg	organic carbon content - sediment (1)
foc - subsurface soil	4171	mg/kg	organic carbon content - soil (1)
Hw	25	cm	average annual recharge - default
Bd	1.67	g/cc	bulk density of soil
Hf	10	cm	wetting from suction - default
Kf	6.90E-04	cm/sec	soil hydraulic conductivity
θ	0.37	decimal %	porosity
Wr	0.08	decimal %	residual water content

(1) The mean total organic carbon content in background samples was used. The background surface soil values were used to assess sediment.

Table C.9
CHARLESTON AFB: FUEL HYDRANT SYSTEM
SOIL TO GROUNDWATER LEACHABILITY MODEL
Chemical-Specific Factors: Sediment and Subsurface Soil

Chemical	Sediment		Subsurface Soil				
	Maximum Detected Concentration (mg/kg)	Distance From Max to Water Table (cm) (1)	Maximum Detected Concentration (mg/kg)	Distance From Max to Water Table (cm) (2)	K_{oc} (ml/g) (3)	H' (mg/l) (3)	$T_{1/2}$ (days) (3)
Benzene	ND	ND	0.0017	61	81	0.226	16
Ethylbenzene	ND	ND	0.017	61	176	0.28	10
Toluene	0.0003	1	0.0027	61	133	0.301	22
Xylene	0.0004	1	0.166	61	639	0.278	28
Naphthalene	ND	ND	0.025	61	1543	0.002	48
Benzo(a)anthracene	0.7	1	0.79	61	1,380,384	0.0002	679
Benzo(b)fluoranthene	1.04	1	1.4	61	549,541	0.0005	610
Benzo(k)fluoranthene	0.36	1	0.5	61	4,365,158	0.043	2,139
Chrysene	0.84	1	1	61	245,471	3.02E-18	993
TPH	20	NA	44	NA	NA	NA	NA

(1) Assumes a distance to groundwater of 1 cm.
(2) Assumes a distance to groundwater of 61 cm (24 inches).
(3) Factors from SCDHEC (1995).

Table C.10
CHARLESTON AFB: FUEL HYDRANT SYSTEM
RESULTS OF THE SOIL TO GROUNDWATER LEACHABILITY MODEL (1)
Subsurface Soil

Parameter	Units	CHEMICAL								
		Benzene	Ethylbenzene	Toluene	Xylene	Naphthalene	Benzo(a) anthracene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Chrysene
f_{cs} - Total Organic Carbon	decimal %	4.20E-03	4.20E-03	4.20E-03	4.20E-03	4.20E-03	4.20E-03	4.20E-03	4.20E-03	4.20E-03
C_w - Leachate Concentration	mg/L	4.17E-03	2.13E-02	4.30E-03	6.26E-02	4.02E-03	1.43E-04	6.36E-04	2.86E-05	1.02E-03
f - Air Filled Porosity	decimal %	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01
t - Infiltration Rate Time	seconds	4.54E+03	4.54E+03	4.54E+03	4.54E+03	4.54E+03	4.54E+03	4.54E+03	4.54E+03	4.54E+03
V_w - Velocity of Water	ft/year	1.39E+04	1.39E+04	1.39E+04	1.39E+04	1.39E+04	1.39E+04	1.39E+04	1.39E+04	1.39E+04
K_d - Soil/Water Distribution Coefficient	ml/g	3.38E-01	7.34E-01	5.55E-01	2.67E+00	6.44E+00	5.76E+03	2.29E+03	1.82E+04	1.02E+03
V_c - Contaminant Percolation Rate	ft/year	2.52E+03	3.22E+03	3.96E+03	1.07E+03	4.62E+02	5.34E-01	1.34E+00	1.69E-01	3.00E+00
T_c - Time to Reach Groundwater	days	2.90E-01	2.27E-01	1.84E-01	6.86E-01	1.58E+00	1.37E+03	5.44E+02	4.32E+03	2.43E+02
C_w - Concentration Reaching Groundwater	mg/L	7.09E-03	1.73E+00	1.71E+00	4.48E+01	2.05E-01	2.83E+00	1.23E+00	1.87E+01	7.82E-01
C_{SSTL} - Site Specific Target Level	mg/kg	1.93E-02	4.70E+00	4.65E+00	1.22E+02	5.56E-01	7.70E+00	3.33E+00	5.09E+01	2.13E+00

(1) Methodology from SCDHEC (1995)

Table C.11
CHARLESTON AFB: FUEL HYDRANT SYSTEM
RESULTS OF THE SOIL TO GROUNDWATER LEACHABILITY MODELING (1)
Sediment

Parameter	Units	Toluene	Xylene	Benzo(a) anthracene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Chrysene
f_{cs} - Total Organic Carbon	decimal %	1.34E-02	1.34E-02	1.34E-02	1.34E-02	1.34E-02	1.34E-02
C_w - Leachate Concentration	mg/L	1.67E-04	4.83E-05	3.96E-05	1.48E-04	6.44E-06	2.67E-04
f - Air Filled Porosity	decimal %	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01	2.90E-01
t - Infiltration Rate Time	seconds	-1.97E+04	-1.97E+04	-1.97E+04	-1.97E+04	-1.97E+04	-1.97E+04
V_w - Velocity of Water	ft/year	2.28E+02	2.28E+02	2.28E+02	2.28E+02	2.28E+02	2.28E+02
K_d - Soil/Water Distribution Coefficient	ml/g	1.78E+00	8.57E+00	1.85E+04	7.37E+03	5.86E+04	3.29E+03
V_c - Contaminant Percolation Rate	ft/year	1.53E+03	3.50E+02	1.66E-01	4.17E-01	5.25E-02	9.34E-01
T_c - Time to Reach Groundwater	days	7.81E-03	3.42E-02	7.21E+01	2.87E+01	2.28E+02	1.28E+01
C_w - Concentration Reaching Groundwater	mg/L	1.70E+00	4.40E+01	7.54E-01	6.82E-01	4.95E+00	6.66E-01
C_{SSTL} - Site Specific Target Level	mg/kg	1.48E+01	3.83E+02	6.56E+00	5.93E+00	4.31E+01	5.80E+00

(1) Methodology from SCDHEC (1995)

Table C.12
Charleston AFB
Fuel Hydrant Site
RBCA Tier 3: Comparison of Detected Concentrations of Benzene to SSTLs - Groundwater

Building/Well	Maximum Detection for Benzene (µg/l)	Modeled Concentration of Benzene at Installation Boundary (µg/l)[1]	SSTL - Tier 3 (µg/l)[2]	Modeled Concentration Exceeds SSTL?
Building 93/MW-11	8.60E+01	4.10E-01	5.00E+00	N
Building 95/MW-8	2.10E+00	1.30E-02	5.00E+00	N
Building 99/MW-3	9.30E+00	7.30E-02	5.00E+00	N

Notes:
1. The concentration of benzene at the installation boundary was derived using....
2. Site-Specific Target Level (SSTL) from Look-up Table 4, SCDHEC, RBCA for Petroleum Releases, 6/95.
Based on residential exposure scenario.

Table C.13
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region III RBCs and Background - Groundwater

Chemical	CAS No.	Frequency of Detection			Maximum Detection (µg/L)	USEPA Reg III RBC (µg/L)[1]		Derived RBC - Industrial (µg/L)[2]		2 X Mean Background Concentration[4]	Retain as COPC? (Yes/No)[5]
Volatile Organics											
n-Butylbenzene	104-51-8	1	/	14	1.80E+00	6.10E+00	N	1.02E+02	N	NA	No - below RBC
Chlorobenzene	108-90-7	1	/	28	4.60E-01	3.90E+00	N	2.04E+02	N	NA	No - below RBC.
Chloromethane	74-87-3	1	/	28	2.00E+00	1.40E+00	C	2.20E+01	C	NA	No - exceeds RBC, but <5% detects (one detect).
Isopropylbenzene	98-82-8	1	/	14	9.20E-01	1.50E+02	N	4.09E+02	N	NA	No - below RBC
p-Isopropyltoluene		1	/	14	2.20E+00	--		--		NA	No RBC
Trichloroethene	79-01-6	1	/	28	1.70E+00	1.60E+00	C	2.60E+01	C	NA	No - exceeds RBC, but <5% detects (one detect).
Semivolatile Organics											
bis(2-ethylhexyl)phthalate	117-81-7	8	/	28	1.60E+01	4.80E+00	C	2.04E+01	C	NA	No - below RBC
Di-n-butyl phthalate	84-74-2	2	/	28	3.20E+00	3.70E+02	N	1.02E+03	N	NA	No - below RBC
Naphthalene	91-20-3	2	/	14	2.30E+00	1.50E+02	N	4.09E+02	N	NA	No - below RBC
Phenol	108-95-2	2	/	28	1.30E+01	2.20E+03	N	6.13E+03	N	NA	No - below RBC
Metals											
Aluminum	7429-90-5	27	/	28	7.90E+05	3.70E+03	N	1.02E+04	N	5.42E+05	Yes - exceeds RBC, 2 X Background
Antimony	7440-36-0	6	/	28	5.10E+01	1.50E+00	N	4.09E+00	N	--	Yes - exceeds RBC
Arsenic (C)	7440-38-2	10	/	28	8.00E+02	4.50E-02	C	1.91E-01	C	9.81E+01	Yes - exceeds RBC, 2 X Background
Barium	7440-39-3	28	/	28	2.50E+03	2.60E+02	N	7.15E+02	N	1.31E+03	Yes - exceeds RBC, 2 X Background
Beryllium	7440-41-7	16	/	28	3.70E+01	1.60E-02	C	6.65E-02	C	1.41E+01	Yes - exceeds RBC, 2 X Background
Cadmium	7440-43-9	2	/	28	5.10E+00	1.80E+00	N	5.11E+00	N	1.20E+01	No - below RBC
Calcium	7440-70-2	28	/	28	3.70E+04	--		--		3.43E+04	No - above 2 X background but essential nutrient.
Chromium (VI)	7440-47-3	24	/	28	9.50E+02	1.80E+00	N	5.11E+01	N	7.13E+02	Yes - exceeds RBC, 2 X Background
Cobalt	7440-48-4	15	/	28	1.20E+03	2.20E+02	N	6.13E+02	N	1.12E+02	Yes - exceeds RBC, 2 X Background
Copper	7440-50-8	20	/	28	3.10E+02	1.50E+02	N	3.80E+02	N	1.46E+02	No - below RBC
Iron	7439-89-6	27	/	28	3.30E+05	1.10E+03	N			2.32E+05	Yes - exceeds RBC, 2 X Background
Lead	7439-92-1	12	/	28	5.50E+02	--		--		2.46E+02	Yes - no RBC, Exceeds 2 X Background
Lithium	7439-93-2	18	/	28	3.00E+02	7.30E+01	N	2.04E+02	N	--	Yes - exceeds RBC
Magnesium	7439-95-4	28	/	28	2.70E+04	--		--		2.77E+04	No - below 2 X background
Manganese	7439-96-5	28	/	28	7.00E+02	1.80E+01	N	5.11E+01	N	7.91E+02	No - below 2 X background
Molybdenum	7439-98-7	4	/	28	4.20E+01	1.80E+01	N	5.11E+01	N	--	No - below RBC

REG4COMP.XLS:gw
4/30/96

Table C.13
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region III RBCs and Background - Groundwater

Chemical	CAS No.	Frequency of Detection	Maximum Detection (μg/L)	USEPA Reg III RBC (μg/L)(1)		Derived RBC - Industrial (μg/L)(2)		2 X Mean Background Concentration(4)	Retain as COPC? (Yes/No)(5)
Nickel	7440-02-0	10 / 28	7.30E+02	7.30E+01	N	2.04E+02	N	2.06E+02	**Yes - exceeds RBC, 2 X Background**
Phosphorus	7723-14-0	10 / 28	3.00E+03	-- (3)		--		--	No - no RBC or background but essential nutrient
Potassium	7440-09-7	27 / 28	2.70E+04	--		--		1.95E+04	No - above 2 X background but essential nutrient.
Selenium	7782-49-2	5 / 28	1.80E+02	1.80E+01	N	5.11E+01	N	2.35E+01	**Yes - exceeds RBC, 2 X Background**
Sodium	7440-23-5	28 / 28	3.30E+04	--		--		1.42E+04	No - above 2 X background but essential nutrient.
Strontium	8001-50-1	28 / 28	4.70E+02	2.20E+03	N	6.13E+03	N	--	No - below RBC
Thallium (chloride)	7440-28-0	1 / 28	1.60E+02	2.90E-01	N			6.53E+00	No - exceeds RBC and background, but <5% detects
Vanadium	7440-62-2	27 / 28	1.40E+03	2.60E+01	N	7.15E+01	N	8.27E+02	**Yes - exceeds RBC, 2 X Background**
Zinc	7440-66-6	14 / 28	1.40E+03	1.10E+03	N	3.07E+03	N	4.94E+02	No - below RBC

Notes:

(1) Risk-Based Concentrations from Region III RBC Table: October 20, 1995. Based on a cancer risk of 1E-06 and a Hazard Index of 0.1.
"N" - noncarcinogen, "C" - carcinogen.
"--" - No Region III RBC available. "RBCA" indicates chemical previously eliminated based on comparison to RBCA Tier 1 RBSL.
(2) "NR" - indicates no Region III RBC.
(3) An RBC is available for white phosphorus only, a very toxic form of phosphorus; this form was not identified in site samples.
(4) 2 X arithmetic average background concentration (detects only).
(5) For organics, chemical retained as COPC if max detect greater than RBC. For inorganics, chemical retained as COPC if max detect greater than RBC and 2 X background, if no RBC and max detect greater than 2 X background, if max detect greater than RBC and no available background data, or if no available RBC or background data.
Chemical not retained as COPC if frequency of detection < 5% with total samples > 20.
Essential nutrients evaluated by comparing intake (maximum concentration x 2L/day) to RDA or SADI (see text) for the following inorganics:

Inorganic	RDA/SADI (mg/day)
Calcium	800-1200
Magnesium	280-400
Phosphorus	800-1200
Potassium	1875-5625
Sodium	1100-3300

Table C.14
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region III RBCs and Background - Subsurface Soil

Chemical	CAS No.	Frequency of Detection	Maximum Detection	USEPA Reg III RBC - Residential (mg/kg)(1)		USEPA Reg III RBC - Industrial (mg/kg)(1)		2 X Mean Background Concentration(4)	Retain as COPC? (Yes/No)(5)
Volatile Organics									
n-Butylbenzene	104-51-8	1 / 12	1.10E-03	7.80E+01	N	2.00E+03	N	NA	No - below RBC
sec-Butylbenzene	135-98-8	1 / 12	6.40E-04	7.80E+01	N	2.00E+03	N	NA	No - below RBC
tert-Butylbenzene	98-06-6	1 / 12	2.70E-03	7.80E+01	N	2.00E+03	N	NA	No - below RBC
Isopropylbenzene	98-82-8	1 / 12	2.00E-03	3.10E+02	N	8.20E+03	N	NA	No - below RBC
p-Isopropyltoluene		2 / 12	6.10E-03	--		--		NA	No RBC
n-Propylbenzene	103-65-1	1 / 12	6.30E-04	--		--		NA	No RBC
1,1,2,2-Tetrachloroethane	79-34-5	1 / 12	1.10E-03	3.20E+00	C	2.90E+01	C	NA	No - below RBC
1,2,4-Trichlorobenzene	120-82-1	1 / 24	7.00E-04	7.80E+01	N	2.00E+03	N	NA	No - below RBC
1,1,1-Trichloroethane	71-55-6	3 / 12	2.10E-03	7.00E+02	N	1.80E+04	N	NA	No - below RBC
Trichloroethene	79-01-6	11 / 12	1.80E-02	5.80E+01	C	5.20E+02	C	NA	No - below RBC
1,2,4-Trimethylbenzene	95-63-6	1 / 12	3.40E-02	3.90E+02	N	1.00E+04	N	NA	No - below RBC
1,3,5-Trimethylbenzene	108-67-8	1 / 12	4.30E-02	3.90E+02	N	1.00E+04	N	NA	No - below RBC
Semivolatile Organics									
Benzo(a)pyrene	50-32-8	1 / 12	8.50E-01	8.80E-02	C	7.80E-01	C	NA	**Yes - exceeds RBC**
Benzo(ghi)perylene	191-24-2	1 / 12	8.00E-01	--		--		NA	No RBC
bis(2-ethylhexyl)phthalate	117-81-7	1 / 12	5.30E-01	4.60E+01	C	4.10E+02	C	NA	No - below RBC
Fluoranthene	206-44-0	1 / 12	1.80E+00	3.10E+02	N	8.20E+03	N	NA	No - below RBC
Indeno(1,2,3-cd)pyrene	193-39-5	1 / 12	8.70E-01	8.80E-01	C	7.80E+00	C	NA	No - below RBC
Phenanthrene	85-01-8	1 / 12	9.90E-01	--		--		NA	No RBC
Pyrene	129-00-0	2 / 12	1.90E+00	2.30E+02	N	6.10E+03	N	NA	No - below RBC
Metals									
Aluminum	7429-90-5	12 / 12	2.90E+04	7.80E+03	N	1.00E+05	N	1.57E+04	No - below RBC
Arsenic	7440-38-2	7 / 12	4.70E+01	4.30E-01	C	3.80E+00	C	3.21E+00	**Yes - exceeds RBC, 2 X Background**
Barium	7440-39-3	12 / 12	1.10E+02	5.50E+02	N	1.40E+04	N	2.05E+01	No - below RBC
Beryllium	7440-41-7	9 / 12	3.20E-01	1.50E-01	C	1.30E+00	C	2.17E-01	No - below RBC
Cadmium	7440-43-9	3 / 12	3.30E-01	3.90E+00	N	1.00E+02	N	--	No - Below RBC
Calcium	7440-70-2	12 / 12	8.00E+04	--		--		1.14E+03	No - Above 2 X background but essential nutrient.
Chromium (IV)	7440-47-3	12 / 12	2.00E+01	3.90E+01	N	1.00E+03	N	1.57E+01	No - below RBC
Cobalt	7440-48-4	11 / 12	3.80E+00	4.70E+02	N	1.20E+04	N	4.00E+00	No - below RBC
Iron	7439-89-6	12 / 12	1.60E+04	2.30E+03	N	6.10E+04	N	8.90E+03	No - below RBC
Lead	7439-92-1	12 / 12	2.30E+01	--		--		1.13E+01	No, below Region IV action limit of 400 mg/kg
Lithium	7439-93-2	12 / 12	1.30E+01	1.60E+02	N	4.10E+03	N	--	No - below RBC

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4/30/96

Table C.14
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region III RBCs and Background - Subsurface Soil

Chemical	CAS No.	Frequency of Detection	Maximum Detection	USEPA Reg III RBC - Residential (mg/kg)[1]		USEPA Reg III RBC - Industrial (mg/kg)[1]		2 X Mean Background Concentration[4]	Retain as COPC? (Yes/No)[5]
Magnesium	7439-95-4	12 / 12	1.10E+03	--		--		3.91E+02	No - Above 2 X background but essential nutrient.
Manganese	7439-96-5	12 / 12	5.00E+01	3.90E+01	N	1.00E+03	N	1.38E+01	No - below RBC
Molybdenum	7439-98-7	1 / 12	1.10E+00	3.90E+01	N	1.00E+03	N --		No - below RBC
Nickel	7440-02-0	12 / 12	6.10E+00	1.60E+02	N	4.10E+03	N	8.40E+00	No - below RBC
Phosphorus	7723-14-0	3 / 12	5.50E+02	-- (3)		-- (3)		--	No - no RBC or background but essential nutrient
Potassium	7440-09-7	12 / 12	1.00E+03	--		--		2.19E+02	No - Above 2 X background but essential nutrient.
Selenium	7782-49-2	3 / 12	1.10E+01	3.90E+01	N	1.00E+03	N	6.00E-01	No - below RBC
Sodium	7440-23-5	6 / 12	1.30E+02	--		--		1.07E+02	No - Above 2 X background but essential nutrient.
Strontium	8001-50-1	12 / 12	8.70E+01	4.70E+03	N	1.00E+05	N	--	No - below RBC
Vanadium	7440-62-2	12 / 12	3.30E+01	5.50E+01	N	1.40E+03	N	2.65E+01	No - below RBC
Zinc	7440-66-6	12 / 12	1.90E+01	2.30E+03	N	6.10E+04	N	1.22E+01	No - below RBC

Notes:

(1) Risk-Based Concentrations from Region III RBC Table: October 20, 1995. Based on a cancer risk of 1E-06 and a Hazard Index of 0.1;
"--" - No Region III RBC available. "RBCA" indicates chemical previously eliminated based on comparison to RBCA Tier 1 RBSL. Residential soil ingestion values used for screening.
"N" - noncarcinogen, "C" - carcinogen.
(2) "NR" - indicates no Region III RBC.
(3) An RBC is available for white phosphorus only, a very toxic form of phosphorus; this form was not identified in site samples.
(4) 2 X arithmetic average subsurface soil background concentration (detects only).
(5) For organics, chemical retained as COPC if max detect greater than RBC. For inorganics, chemical retained as COPC if max detect greater than RBC and 2 X background, if no RBC and max detect greater than 2 X background, if max detect greater than RBC and no available background data, or if no available RBC or background data.
Chemical not retained as COPC if frequency of detection < 5% with total samples > 20.
Essential nutrients evaluated by comparing intake (maximum concentration x 200 mg/day) to RDA or SADI (see text) for the following inorganics:

Inorganic	RDA/SADI (mg/day)
Calcium	800-1200
Magnesium	280-400
Phosphorus	800-1200
Potassium	1875-5625
Sodium	1100-3300

Table C.15
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to Surface Water Criteria

Chemical	CAS No.	Frequency of Detection	Maximum Detection (µg/L)	Human Health WQC[1]		Retain as Human Health COPC? (Yes/No)[2]	Ecological - FSV - Acute (ug/L)[3]	Ecological - FSV - Chronic (ug/L)[3]	Retain as Ecological COPC? (Yes/No)[2]
Volatile Organics									
Ethylbenzene	100-41-4	1 / 8	1.10E+00	3.10E+03	N	No - below WQC.	4.53E+03	4.53E+02	No - below chronic screening value
m,p-Xylene		1 / 8	1.20E+00	--		No WQC	--	--	No Region IV screening value
TPH									
TPH-JP4		4 / 8	5.70E+02	--		No WQC	--	--	No Region IV screening value
Semivolatile Organics									
Benzo(a)pyrene	50-32-8	1 / 8	1.40E+00	2.80E-03	C	Yes - exceeds WQC	--	--	No Region IV screening value
Benzo(b)fluoranthene	205-99-2	1 / 8	2.60E+00	2.80E-03	C	Yes - exceeds WQC	--	--	No Region IV screening value
bis(2-ethylhexyl)phthalate	117-81-7	1 / 8	6.00E+00	1.80E+00	C	Yes - exceeds WQC	1.11E+03	<0.3	Yes - exceeds chronic screening value
Chrysene	218-01-9	1 / 8	1.90E+00	2.80E-03	C	Yes - exceeds WQC	--	--	No Region IV screening value
Di-n-butyl phthalate	84-74-2	1 / 8	1.80E+00	2.70E+03	N	No - below WQC.	9.40E+01	9.40E+00	No - below chronic screening value
Fluoranthene	206-44-0	1 / 8	4.30E+00	3.00E+02	N	No - below WQC.	3.98E+02	3.98E+01	No - below chronic screening value
Phenanthrene	85-01-8	1 / 8	2.20E+00	--		No WQC	--	--	No Region IV screening value
Pyrene	129-00-0	1 / 8	3.60E+00	2.80E-03	N	Yes - exceeds WQC	--	--	No Region IV screening value
Metals									--
Aluminum	7429-90-5	8 / 8	7.80E+03	--		No WQC	7.50E+02	8.70E+01	Yes - exceeds chronic screening value
Calcium	7440-70-2	8 / 8	2.00E+04	--		No WQS, but essential nutrient	--	--	No Region IV screening value
Chromium (III)	7440-47-3	1 / 8	5.30E+00	3.30E+04	N	No - below WQC.	1.60E+01	1.10E+01	No - below chronic screening value
Copper	7440-50-8	1 / 8	9.60E+00	--		No WQC	9.22E+00	6.54E+00	Yes - exceeds chronic screening value
Iron	7439-89-6	8 / 8	1.70E+04	3.00E+02	N	Yes - exceeds WQC	--	1.00E+03	Yes - exceeds chronic screening value
Lithium	7439-93-2	4 / 8	4.20E+00	--		No WQC	--	--	No Region IV screening value
Magnesium	7439-95-4	8 / 8	2.20E+03	--		No WQS, but essential nutrient	--	--	No Region IV screening value
Manganese	7439-96-5	8 / 8	5.50E+01	5.00E+01	N	Yes - exceeds WQC	--	--	No Region IV screening value
Phosphorus	7723-14-0	8 / 8	6.40E+02	--		No WQS, but essential nutrient	--	--	No Region IV screening value
Potassium	7440-09-7	8 / 8	1.20E+03	--		No WQS, but essential nutrient	--	--	No Region IV screening value
Sodium	7440-23-5	8 / 8	7.40E+03	--		No WQS, but essential nutrient	--	--	No Region IV screening value
Strontium	8001-50-1	8 / 8	1.00E+02	--		No WQC	--	--	No Region IV screening value
Vanadium	7440-62-2	1 / 8	1.30E+01	--		No WQC	--	--	No Region IV screening value
Zinc	7440-66-6	4 / 8	2.90E+01	--		No WQC	6.50E+01	5.89E+01	No - below chronic screening value

Notes:
(1) Water Quality Criteria (WQC) Summary Concentrations for ingestion of water and organisms (USEPA, 8/94). Based on a cancer risk of 1E-06.
"N" - noncarcinogen, "C" - carcinogen.
"--" - No WQC.

Table C.16
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region III RBCs and Background - Sediment

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	USEPA Reg III RBC - Residential (mg/kg)[1]		USEPA Reg III RBC - Industrial (mg/kg)[1]		2 X Mean Background Concentration (mg/kg)[2]	Retain as COPC? (Yes/No)[5]
Volatile Organics									
Methylene chloride	75-09-2	1 / 7	2.60E-03	8.50E+01	C	7.60E+02	C	NA	No - below RBC
Trichloroethene	79-01-6	7 / 7	5.20E-03	5.80E+01	C	5.20E+02	C	NA	No - below RBC
Trichlorofluoromethane	75-69-4	1 / 7	9.10E-03	2.30E+03	N	6.10E+04	N	NA	No - below RBC
Semivolatile Organics									
Benzo(a)pyrene	50-32-8	4 / 7	6.40E-01	8.80E-02	C	7.80E-01	C	NA	No - below RBC
Benzo(ghi)perylene	191-24-2	4 / 7	7.80E-01	--		--		NA	No RBC
Fluoranthene	206-44-0	5 / 7	1.60E+00	3.10E+02	N	8.20E+03	N	NA	No - below RBC
Indeno(1,2,3-cd)pyrene	193-39-5	3 / 7	6.10E-01	8.80E-01	C	7.80E-01	C	NA	No - below RBC
Phenanthrene	85-01-8	5 / 7	9.60E-01	--		--		NA	No RBC
Pyrene	129-00-0	5 / 7	2.00E+00	2.30E+02	N	6.10E+03	N	NA	No - below RBC
Metals									
Aluminum	7429-90-5	7 / 7	2.80E+04	7.80E+03	N	1.00E+05	N	9.92E+03	No - below RBC
Arsenic	7440-38-2	1 / 7	4.40E+01	4.30E-01	C	3.80E+00	C	6.60E+00	**Yes - exceeds RBC, 2 X Background**
Barium	7440-39-3	7 / 7	6.50E+01	5.50E+02	N	1.40E+04	N	2.63E+01	No - below RBC
Cadmium	7440-43-9	2 / 7	2.60E-01	3.90E+00	N	1.00E+02	N	NR	No - below RBC
Calcium	7440-70-2	7 / 7	1.40E+04	--		--		2.38E+03	No - above 2 X background but essential nutrient.
Chromium (IV)	7440-47-3	7 / 7	1.50E+01	3.90E+01	N	1.00E+03	N	1.55E+01	No - below RBC
Cobalt	7440-48-4	4 / 7	1.30E+00	4.70E+02	N	1.20E+04	N	3.00E+00	No - below RBC
Iron	7439-89-6	6 / 7	2.90E+03	2.30E+03	N	6.10E+04	N	1.08E+04	No - below 2 X background
Lead	7439-92-1	7 / 7	1.30E+01	--		--		2.83E+01	No - below 2 X background
Lithium	7439-93-2	7 / 7	9.20E+00	1.60E+02	N	4.10E+03	N	NR	No - below RBC
Magnesium	7439-95-4	7 / 7	4.60E+02	--		--		3.16E+02	No - above 2 X background but essential nutrient.
Manganese	7439-96-5	7 / 7	2.90E+01	3.90E+01	N	1.00E+03	N	1.52E+01	No - below RBC
Nickel	7440-02-0	7 / 7	4.50E+00	1.60E+02	N	4.10E+03	N	1.46E+01	No - below RBC
Phosphorus	7723-14-0	6 / 7	3.10E+02	--[3]		--[3]		NR	No - essential nutrient.
Potassium	7440-09-7	6 / 7	4.20E+02	--		--		NR	No - essential nutrient.
Strontium	8001-50-1	7 / 7	1.20E+01	4.70E+03	N	1.00E+05	N	NR	No - below RBC
Vanadium	7440-62-2	7 / 7	1.30E+01	5.50E+01	N	1.40E+03	N	1.95E+01	No - below RBC
Zinc	7440-66-6	7 / 7	6.00E+01	2.30E+03	N	6.10E+04	N	1.17E+01	No - below RBC

Notes:

(1) Risk-Based Concentrations from Region III RBC Table: October 20, 1995. Based on a cancer risk of 1E-06 and a Hazard Index of 0.1.

REG4COMP.XLS:sd (hh)
4/30/96

Table C.16
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region III RBCs and Background - Sediment

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	USEPA Reg III RBC - Residential (mg/kg)[1]	USEPA Reg III RBC - Industrial (mg/kg)[1]	2 X Mean Background Concentration (mg/kg)[2]	Retain as COPC? (Yes/No)[5]

"–" - No Region III RBC available. "RBCA" indicates chemical previously eliminated based on comparison to RBCA Tier 1 RBSL.
"N" - noncarcinogen, "C" - carcinogen.
(2) "NR" - indicates no Region III RBC, chemical carried to next step in Region IV screening process.
(3) An RBC is available for white phosphorus only, a very toxic form of phosphorus; this form was not identified in site samples.
(4) 2 X arithmetic average background concentration for surface soil (detects only).
(5) For organics, chemical retained as COPC if max detect greater than RBC. For inorganics, chemical retained as COPC if max detect greater than RBC and 2 X background, if no RBC and max detect greater than 2 X background, if max detect greater than RBC and no available background data, or if no available RBC or background data.
Chemical not retained as COPC if frequency of detection < 5% with total samples > 20.
Essential nutrients evaluated by comparing intake (maximum concentration x 200 mg/day) to RDA or SADI (see text) for the following inorganics:

Inorganic	RDA/SADI (mg/day)
Calcium	800-1200
Magnesium	280-400
Phosphorus	800-1200
Potassium	1875-5625
Sodium	1100-3300

Table C.17
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region IV Sediment Screening Values and Background - Sediment

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	Screening Value (mg/kg)[1]	2 X Mean Background Concentration[2]	Retain as COPC? (Yes/No)[3]
Volatile Organics						
Methylene chloride	75-09-2	1 / 7	2.60E-03	--	NA	No Region IV screening value
Toluene	108-88-3	1 / 7	3.00E-04	--	NA	No Region IV screening value
Trichloroethene	79-01-6	7 / 7	5.20E-03	--	NA	No Region IV screening value
Trichlorofluoromethane	75-69-4	1 / 7	9.10E-03	--	NA	No Region IV screening value
m,p-Xylene		1 / 7	4.00E-04	--	NA	No Region IV screening value
TPH						
TPH-JP4		6 / 7	2.00E+01	--	NA	No Region IV screening value
Semivolatile Organics						
Benzo(a)anthracene	56-55-3	4 / 7	7.00E-01	3.30E-01	NA	Yes - exceeds screening value
Benzo(a)pyrene	50-32-8	4 / 7	6.40E-01	3.30E-01	NA	Yes - exceeds screening value
Benzo(b)fluoranthene	205-99-2	5 / 7	1.04E+00	--	NA	No Region IV screening value
Benzo(ghi)perylene	191-24-2	4 / 7	7.80E-01	--	NA	No Region IV screening value
Benzo(k)fluoranthene	207-08-9	2 / 7	3.60E-01	--	NA	No Region IV screening value
Chrysene	218-01-9	5 / 7	8.40E-01	3.30E-01	NA	Yes - exceeds screening value
Fluoranthene	206-44-0	5 / 7	1.60E+00	3.80E-01	NA	Yes - exceeds screening value
Indeno(1,2,3-cd)pyrene	193-39-5	3 / 7	6.10E-01	--	NA	No Region IV screening value
Phenanthrene	85-01-8	5 / 7	9.60E-01	3.30E-01	NA	Yes - exceeds screening value
Pyrene	129-00-0	5 / 7	2.00E+00	3.30E-01	NA	Yes - exceeds screening value
Metals						
Aluminum	7429-90-5	7 / 7	2.80E+04	--	9.92E+03	Yes - no Region IV screening value, exceeds background
Arsenic	7440-38-2	1 / 7	4.40E+01	8.00E+00	6.60E+00	Yes - exceeds screening value, exceeds background
Barium	7440-39-3	7 / 7	6.50E+01	--	2.63E+01	Yes - no Region IV screening value, exceeds background
Cadmium	7440-43-9	2 / 7	2.60E-01	1.00E+00	NR	No - below screening value
Calcium	7440-70-2	7 / 7	1.40E+04	--	2.38E+03	Yes - no Region IV screening value, exceeds background
Chromium	7440-47-3	7 / 7	1.50E+01	3.30E+01	1.55E+01	No - below screening value
Cobalt	7440-48-4	4 / 7	1.30E+00	--	3.00E+00	No - below background

REG4COMP.XLS:sd (eco)
4/30/96

Table C.17
Charleston AFB
Fuel Hydrant Site
Comparison of Detected Concentrations to USEPA Region IV Sediment Screening Values and Background - Sediment

Chemical	CAS No.	Frequency of Detection	Maximum Detection (mg/kg)	Screening Value (mg/kg)(1)	2 X Mean Background Concentration(2)	Retain as COPC? (Yes/No)(3)
Iron	7439-89-6	6 / 7	2.90E+03	--	1.08E+04	No - below background
Lead	7439-92-1	7 / 7	1.30E+01	2.10E+01	2.83E+01	No - below screening value
Lithium	7439-93-2	7 / 7	9.20E+00	--	NR	**Yes - no Region IV screening value or background data**
Magnesium	7439-95-4	7 / 7	4.60E+02	--	3.16E+02	**Yes - no Region IV screening value, exceeds background**
Manganese	7439-96-5	7 / 7	2.90E+01	--	1.52E+01	**Yes - no Region IV screening value, exceeds background**
Nickel	7440-02-0	7 / 7	4.50E+00	2.09E+01	1.46E+01	No - below screening value
Phosphorus	7723-14-0	6 / 7	3.10E+02	--	NR	**Yes - no Region IV screening value or background data**
Potassium	7440-09-7	6 / 7	4.20E+02	--	NR	**Yes - no Region IV screening value or background data**
Strontium	8001-50-1	7 / 7	1.20E+01	--	NR	**Yes - no Region IV screening value or background data**
Vanadium	7440-62-2	7 / 7	1.30E+01	--	1.95E+01	No - below background
Zinc	7440-66-6	7 / 7	6.00E+01	6.80E+01	1.17E+01	No - below screening value

Notes:
(1) USEPA Region IV Waste Management Division Screening Values for Hazardous Waste Sites, 2/16/94.
"--" - No Region IV sediment screening value.
(2) Retained as COPC if maximum detected concentration exceeds sediment screening value or surface soil background (inorganics only), or if no Region IV sediment screening value available.

APPENDIX D

1-D ANALYTICAL SOLUTE TRANSPORT MODEL

TRANSPORT SIMULATION OF GENERIC SOLUTE AT SS-41USING A ONE-DIMENSIONAL SOLUTE TRANSPORT MODEL (Foc = 0.0%) FROM MW-3 to Base Boundary (4,800 ft)

Hydrogeologic Data

Hydraulic conductivity (S & ME, 1993)	$K := 2.5 \cdot 10^{-2} \cdot \frac{cm}{sec}$	$K = 70.866 \cdot \frac{ft}{day}$
Hydraulic gradient (AFCEE, 1994)	$I := 0.0032 \cdot \frac{ft}{ft}$	
Effective porosity (Assumption)	$n_e := 0.3$	
Total porosity (Freeze and Cherry, 1979)	$n := 0.37$	
Longitudinal dispersivity (EPRI, 1985)	$\alpha_L := 152.4 \cdot m$	$\alpha_L = 500 \cdot ft$

Retardation Coefficient Calculation

Organic carbon partition coefficient (EPA, 1990)	$K_{oc} := 0 \cdot \frac{mL}{gm}$	
Particle mass density (Freeze and Cherry, 1979)	$\rho_s := 2.65 \cdot \frac{gm}{cm^3}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := \rho_s \cdot (1 - n)$	$\rho_b = 1.67 \cdot \frac{gm}{cm^3}$
Organic carbon fraction content (Assumed 0.0)	$f_{oc} := 0.0 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1$

Groundwater Hydraulics Calculations

Groundwater velocity (Darcy)	$v_d := K \cdot I$	$v_d = 0.227 \cdot \frac{ft}{day}$
Groundwater velocity (pore-water)	$v_p := \frac{v_d}{n_e}$	$v_p = 0.756 \cdot \frac{ft}{day}$
Constituent velocity	$v_c := \frac{v_p}{R}$	$v_c = 0.756 \cdot \frac{ft}{day}$
Longitudinal dispersion coefficient	$D_L := \alpha_L \cdot v_c$	$D_L = 377.953 \cdot \frac{ft^2}{day}$

Initial Plume Distribution Calculation

Constituent concentration at source location (MW-3)

$$C_{source} := (1)\cdot\frac{gm}{liter}$$

Idealized length of the constituent plume (assumed) $L := 100\cdot ft$

Time required to form a plume of length, L, and source (maximum) concentration, Csource (Fischer, 1979)

$$\tau := \frac{\left(\frac{L}{6}\right)^2}{2\cdot D_L} \qquad \tau = 0.367\cdot day$$

Distance required to form a plume of length, L, and source (maximum) concentration, Csource

$$\delta := v_c\cdot\tau \qquad \delta = 0.278\cdot ft$$

Idealized mass introduced per unit area (saturated thickness by width of porous media)

$$M := C_{source}\cdot n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot\tau} \qquad M = 0.438\cdot\frac{kg}{ft^2}$$

Spatial limits for the graph of initial constitient distribution

$$\Delta x := \frac{2\cdot L}{200} \qquad j := 1..201$$

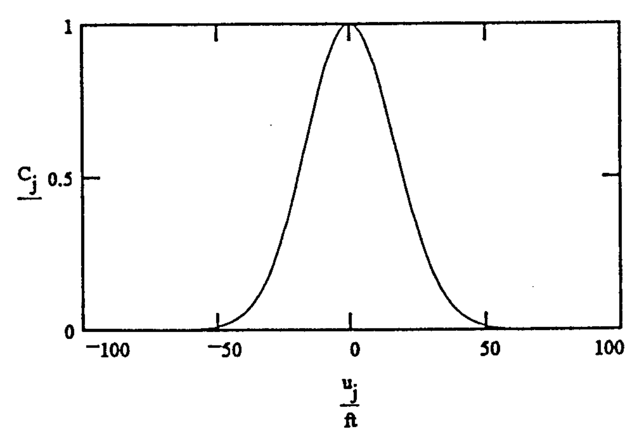
$$x_j := \Delta x\cdot j - (L + \Delta x - \delta)$$

$$u_j := x_j - \delta$$

One-dimensional advective-dispersive solute transport solution (Bear, 1979)

$$C_j := \frac{M}{n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot\tau}}\cdot\exp\left[-\frac{\left(x_j - v_c\cdot\tau\right)^2}{4\cdot D_L\cdot\tau}\right]$$

INITIAL CONSTITUENT DISTRIBUTION (Concentration vs. Distance where u=0 represents the actual location of the consituent source)



Constituent Arrival at Base Boundary

Distance from the source (MW-3) to the receptor $d_r := 4800 \cdot ft$ $d_r = 1.463 \cdot 10^3 \cdot m$

Temporal limits of arrival curve graph at the receptor location

$$j := 1..7000$$

$$\Delta T := 5 \cdot day$$

$$T_j := j \cdot \Delta T$$

Transformation of time and distance scales to include intial plume distribution

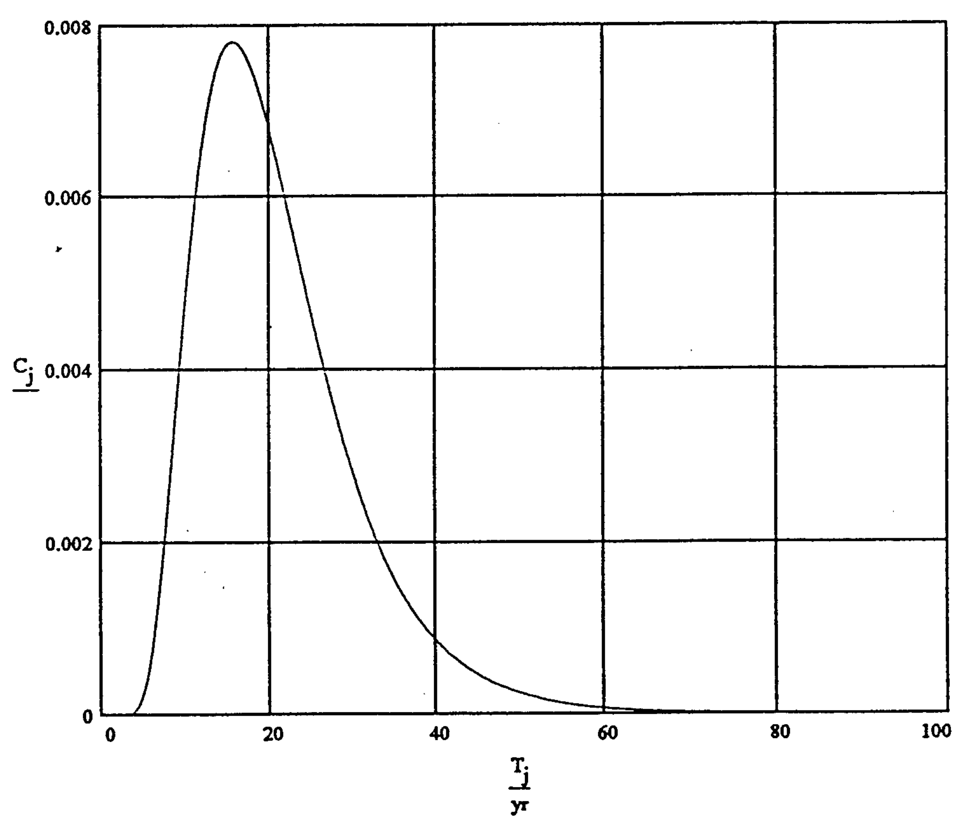
$$x := \delta + d_r$$

$$t_j := \tau + T_j$$

One-dimensional advective-dispersive solute transport solution (Bear, 1979)

$$C_j := \frac{M}{n \cdot \sqrt{4 \cdot \pi \cdot D_L \cdot t_j}} \cdot \exp\left[-\frac{\left(x - v_c \cdot t_j\right)^2}{4 \cdot D_L \cdot t_j} \right]$$

ARRIVAL OF SOLUTE AT BASE BOUNDARY



Peak Concentration and Peak Arrival Time Calculations

The peak arrival time is calculated by setting the time derivative of the 1-D solute transport solution (Bear, 1979) to zero and solving for the time variable.

Initial estimate for arrival of peak at the receptor $\quad t_a := \frac{d_r}{v_c}$

Given

$$0\cdot\frac{gm}{liter\cdot day} = \frac{-1}{4}\cdot\frac{M}{\left[n\cdot\left[\sqrt{\pi}\cdot\left[\sqrt{D_L\cdot t_a}^{\left(\frac{3}{2}\right)}\right]\right]\right]}\cdot\exp\left[\frac{-1}{4}\cdot\frac{(x-v_c\cdot t_a)^2}{(D_L\cdot t_a)}\right]\ldots$$

$$+\frac{1}{2}\cdot\frac{M}{\left[n\cdot\left[\sqrt{\pi}\cdot\left(\sqrt{D_L}\cdot\sqrt{t_a}\right)\right]\right]}\cdot\left[\frac{1}{2}\cdot\frac{(x-v_c\cdot t_a)}{(D_L\cdot t_a)}\cdot v_c+\frac{1}{4}\cdot\frac{(x-v_c\cdot t_a)^2}{\left(D_L\cdot t_a^{\,2}\right)}\right]\cdot\exp\left[\frac{-1}{4}\cdot\frac{(x-v_c\cdot t_a)^2}{(D_L\cdot t_a)}\right]$$

$$t_p := \mathrm{find}(t_a)$$

Peak arrival time at Base Boundary

$t_{peak} := t_p - \tau \qquad t_{peak} = 15.669\cdot yr$

Peak concentration at Base Boundary

$$C_{peak} := \frac{M}{n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot t_p}}\cdot\exp\left[-\frac{(x-v_c\cdot t_p)^2}{4\cdot D_L\cdot t_p}\right] \qquad C_{peak} = 0.0078\cdot\frac{gm}{liter}$$

$ppb := C_{peak}\cdot 10^6$

$ppb = 7.808\cdot 10^3\cdot kg\cdot m^{-3}$

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TRANSPORT SIMULATION OF GENERIC SOLUTE AT SS-41USING A ONE-DIMENSIONAL SOLUTE TRANSPORT MODEL (Foc = 0.0%) FROM MW-7 to Base Boundary (6,000 ft)

Hydrogeologic Data

Hydraulic conductivity (S & ME, 1993) $K := 2.5 \cdot 10^{-2} \cdot \frac{cm}{sec}$ $K = 70.866 \cdot \frac{ft}{day}$

Hydraulic gradient (AFCEE, 1994) $I := 0.0032 \cdot \frac{ft}{ft}$

Effective porosity (Assumption) $n_e := 0.3$

Total porosity (Freeze and Cherry, 1979) $n := 0.37$

Longitudinal dispersivity (EPRI, 1985) $\alpha_L := 182.88 \cdot m$ $\alpha_L = 600 \cdot ft$

Retardation Coefficient Calculation

Organic carbon partition coefficient (EPA, 1990) $K_{oc} := 0 \cdot \frac{mL}{gm}$

Particle mass density (Freeze and Cherry, 1979) $\rho_s := 2.65 \cdot \frac{gm}{cm^3}$

Bulk density (Freeze and Cherry, 1979) $\rho_b := \rho_s \cdot (1 - n)$ $\rho_b = 1.67 \cdot \frac{gm}{cm^3}$

Organic carbon fraction content (Assumed 0.0) $f_{oc} := 0.0 \cdot \%$

Retardation coefficient $R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$

$R = 1$

Groundwater Hydraulics Calculations

Groundwater velocity (Darcy) $v_d := K \cdot I$ $v_d = 0.227 \cdot \frac{ft}{day}$

Groundwater velocity (pore-water) $v_p := \frac{v_d}{n_e}$ $v_p = 0.756 \cdot \frac{ft}{day}$

Constituent velocity $v_c := \frac{v_p}{R}$ $v_c = 0.756 \cdot \frac{ft}{day}$

Longitudinal dispersion coefficient $D_L := \alpha_L \cdot v_c$ $D_L = 453.543 \cdot \frac{ft^2}{day}$

Initial Plume Distribution Calculation

Constituent concentration at source location (MW-7)

$$C_{source} := (1)\cdot\frac{gm}{liter}$$

Idealized length of the constituent plume (assumed) $L := 100\cdot ft$

Time required to form a plume of length, L, and source (maximum) concentration, Csource (Fischer, 1979)

$$\tau := \frac{\left(\frac{L}{6}\right)^2}{2\cdot D_L} \qquad \tau = 0.306\cdot day$$

Distance required to form a plume of length, L, and source (maximum) concentration, Csource

$$\delta := v_c\cdot\tau \qquad \delta = 0.231\cdot ft$$

Idealized mass introduced per unit area (saturated thickness by width of porous media)

$$M := C_{source}\cdot n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot\tau} \qquad M = 0.438\cdot\frac{kg}{ft^2}$$

Spatial limits for the graph of initial constitient distribution

$$\Delta x := \frac{2\cdot L}{200} \qquad j := 1 .. 201$$

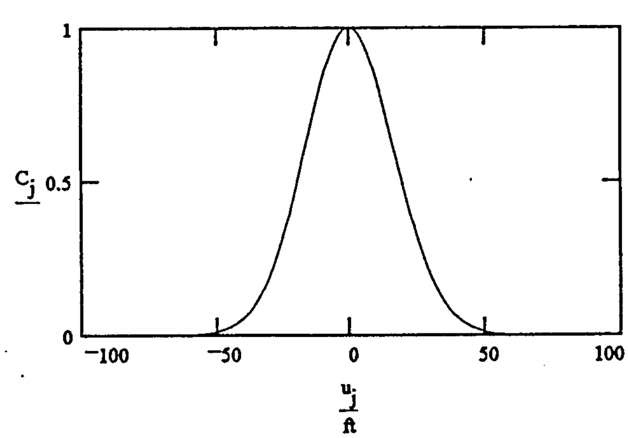
$$x_j := \Delta x\cdot j - (L + \Delta x - \delta)$$

$$u_j := x_j - \delta$$

One-dimensional advective-dispersive solute transport solution (Bear, 1979)

$$C_j := \frac{M}{n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot\tau}}\cdot\exp\left[-\frac{\left(x_j - v_c\cdot\tau\right)^2}{4\cdot D_L\cdot\tau}\right]$$

INITIAL CONSTITUENT DISTRIBUTION (Concentration vs. Distance where u=0 represents the actual location of the consitుent source)



Constituent Arrival at Base Boundary

Distance from the source (MW-7) to the receptor $d_r := 6000 \cdot ft$ $d_r = 1.829 \cdot 10^3 \cdot m$

Temporal limits of arrival curve graph at the receptor location

$$j := 1..7000$$

$$\Delta T := 5 \cdot day$$

$$T_j := j \cdot \Delta T$$

Transformation of time and distance scales to include intial plume distribution

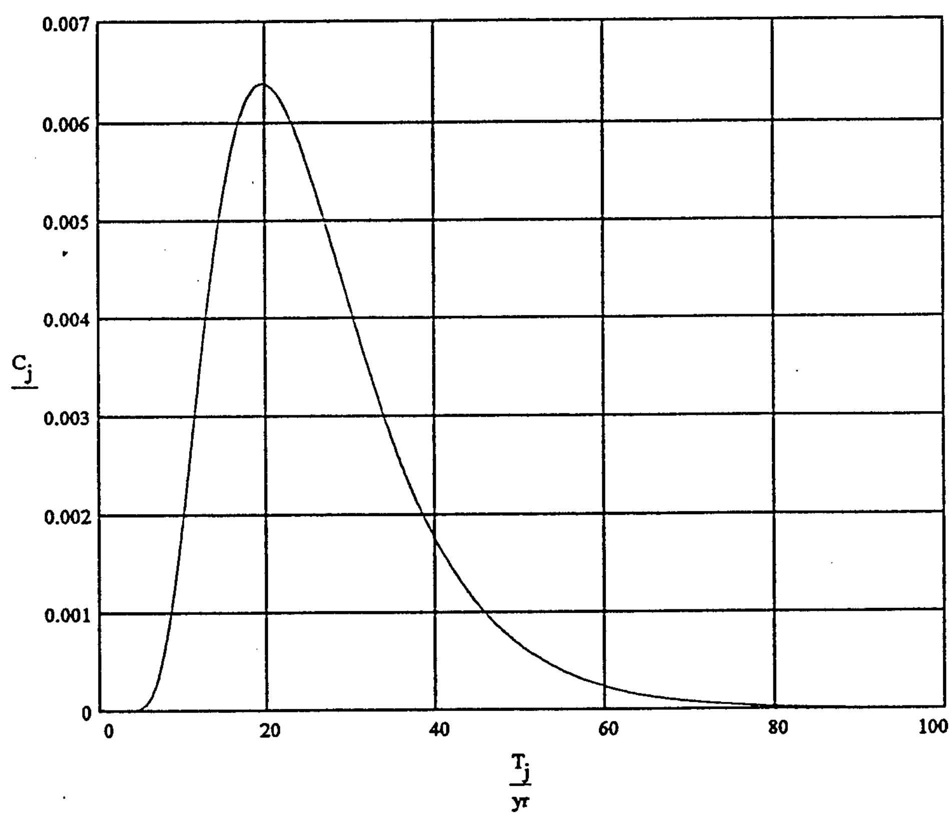
$$x := \delta + d_r$$

$$t_j := \tau + T_j$$

One-dimensional advective-dispersive solute transport solution (Bear, 1979)

$$C_j := \frac{M}{n \cdot \sqrt{4 \cdot \pi \cdot D_L \cdot t_j}} \cdot \exp\left[-\frac{\left(x - v_c \cdot t_j\right)^2}{4 \cdot D_L \cdot t_j} \right]$$

ARRIVAL OF SOLUTE AT BASE BOUNDARY



Peak Concentration and Peak Arrival Time Calculations

The peak arrival time is calculated by setting the time derivative of the 1-D solute transport solution (Bear, 1979) to zero and solving for the time variable.

Initial estimate for arrival of peak at the receptor $t_a := \frac{d_r}{v_c}$

Given

$$0 \cdot \frac{gm}{liter \cdot day} = \frac{-1}{4} \cdot \frac{M}{\left[n \cdot \left[\sqrt{\pi} \cdot \left[\sqrt{D_L \cdot t_a}^{\left(\frac{3}{2}\right)}\right]\right]\right]} \cdot \exp\left[\frac{-1}{4} \cdot \frac{\left(x - v_c \cdot t_a\right)^2}{\left(D_L \cdot t_a\right)}\right] \ldots$$
$$+ \frac{1}{2} \cdot \frac{M}{\left[n \cdot \left[\sqrt{\pi} \cdot \left(\sqrt{D_L} \cdot \sqrt{t_a}\right)\right]\right]} \cdot \left[\frac{1}{2} \cdot \frac{\left(x - v_c \cdot t_a\right)}{\left(D_L \cdot t_a\right)} \cdot v_c + \frac{1}{4} \cdot \frac{\left(x - v_c \cdot t_a\right)^2}{\left(D_L \cdot t_a^2\right)}\right] \cdot \exp\left[\frac{-1}{4} \cdot \frac{\left(x - v_c \cdot t_a\right)^2}{\left(D_L \cdot t_a\right)}\right]$$

$t_p := \mathrm{find}(t_a)$

Peak arrival time at Base Boundary

$t_{peak} := t_p - \tau$ $\qquad$ $t_{peak} = 19.667 \cdot yr$

Peak concentration at Base Boundary

$$C_{peak} := \frac{M}{n \cdot \sqrt{4 \cdot \pi \cdot D_L \cdot t_p}} \cdot \exp\left[-\frac{\left(x - v_c \cdot t_p\right)^2}{4 \cdot D_L \cdot t_p}\right] \qquad C_{peak} = 0.0064 \cdot \frac{gm}{liter}$$

$ppb := C_{peak} \cdot 10^6$

$ppb = 6.368 \cdot 10^3 \cdot kg \cdot m^{-3}$

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Bear, J., Hydraulics of Groundwater, McGraw-Hill, 1979.

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TRANSPORT SIMULATION OF GENERIC SOLUTE AT SS-41USING A ONE-DIMENSIONAL SOLUTE TRANSPORT MODEL (Foc = 0.0%) FROM MW-11 to Base Boundary (8,000 ft)

Hydrogeologic Data

Hydraulic conductivity (S & ME, 1993)	$K := 2.5 \cdot 10^{-2} \cdot \frac{cm}{sec}$	$K = 70.866 \cdot \frac{ft}{day}$
Hydraulic gradient (AFCEE, 1994)	$I := 0.0032 \cdot \frac{ft}{ft}$	
Effective porosity (Assumption)	$n_e := 0.3$	
Total porosity (Freeze and Cherry, 1979)	$n := 0.37$	
Longitudinal dispersivity (EPRI, 1985)	$\alpha_L := 243.84 \cdot m$	$\alpha_L = 800 \cdot ft$

Retardation Coefficient Calculation

Organic carbon partition coefficient (EPA, 1990)	$K_{oc} := 0 \cdot \frac{mL}{gm}$	
Particle mass density (Freeze and Cherry, 1979)	$\rho_s := 2.65 \cdot \frac{gm}{cm^3}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := \rho_s \cdot (1 - n)$	$\rho_b = 1.67 \cdot \frac{gm}{cm^3}$
Organic carbon fraction content (Assumed 0.0)	$f_{oc} := 0.0 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	
	$R = 1$	

Groundwater Hydraulics Calculations

Groundwater velocity (Darcy)	$v_d := K \cdot I$	$v_d = 0.227 \cdot \frac{ft}{day}$
Groundwater velocity (pore-water)	$v_p := \frac{v_d}{n_e}$	$v_p = 0.756 \cdot \frac{ft}{day}$
Constituent velocity	$v_c := \frac{v_p}{R}$	$v_c = 0.756 \cdot \frac{ft}{day}$
Longitudinal dispersion coefficient	$D_L := \alpha_L \cdot v_c$	$D_L = 604.724 \cdot \frac{ft^2}{day}$

Initial Plume Distribution Calculation

Constituent concentration at source location (MW-11)

$$C_{source} := (1)\cdot\frac{gm}{liter}$$

Idealized length of the constituent plume (assumed) $L := 100\cdot ft$

Time required to form a plume of length, L, and source (maximum) concentration, Csource (Fischer, 1979)

$$\tau := \frac{\left(\frac{L}{6}\right)^2}{2\cdot D_L} \qquad \tau = 0.23\cdot day$$

Distance required to form a plume of length, L, and source (maximum) concentration, Csource

$$\delta := v_c\cdot\tau \qquad \delta = 0.174\cdot ft$$

Idealized mass introduced per unit area (saturated thickness by width of porous media)

$$M := C_{source}\cdot n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot\tau} \qquad M = 0.438\cdot\frac{kg}{ft^2}$$

Spatial limits for the graph of initial constitient distribution

$$\Delta x := \frac{2\cdot L}{200} \qquad j := 1..201$$

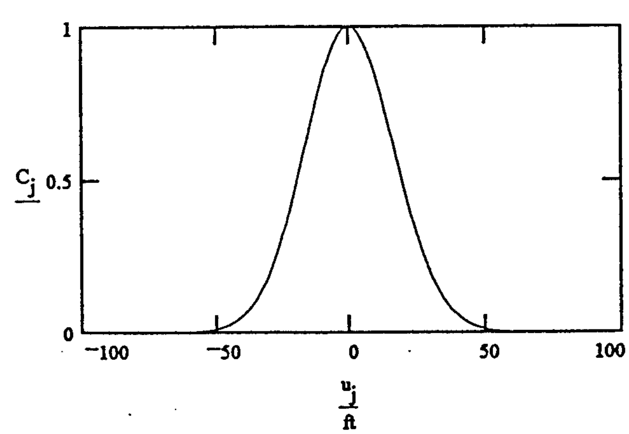
$$x_j := \Delta x\cdot j - (L + \Delta x - \delta)$$

$$u_j := x_j - \delta$$

One-dimensional advective-dispersive solute transport solution (Bear, 1979)

$$C_j := \frac{M}{n\cdot\sqrt{4\cdot\pi\cdot D_L\cdot\tau}}\cdot\exp\left[-\frac{\left(x_j - v_c\cdot\tau\right)^2}{4\cdot D_L\cdot\tau}\right]$$

INITIAL CONSTITUENT DISTRIBUTION (Concentration vs. Distance where u=0 represents the actual location of the consituent source)



Constituent Arrival at Base Boundary

Distance from the source (MW-11) to the receptor $d_r := 8000 \cdot ft$ $d_r = 2.438 \cdot 10^3 \cdot m$

Temporal limits of arrival curve graph at the receptor location

$$j := 1..7000$$

$$\Delta T := 5 \cdot day$$

$$T_j := j \cdot \Delta T$$

Transformation of time and distance scales to include intial plume distribution

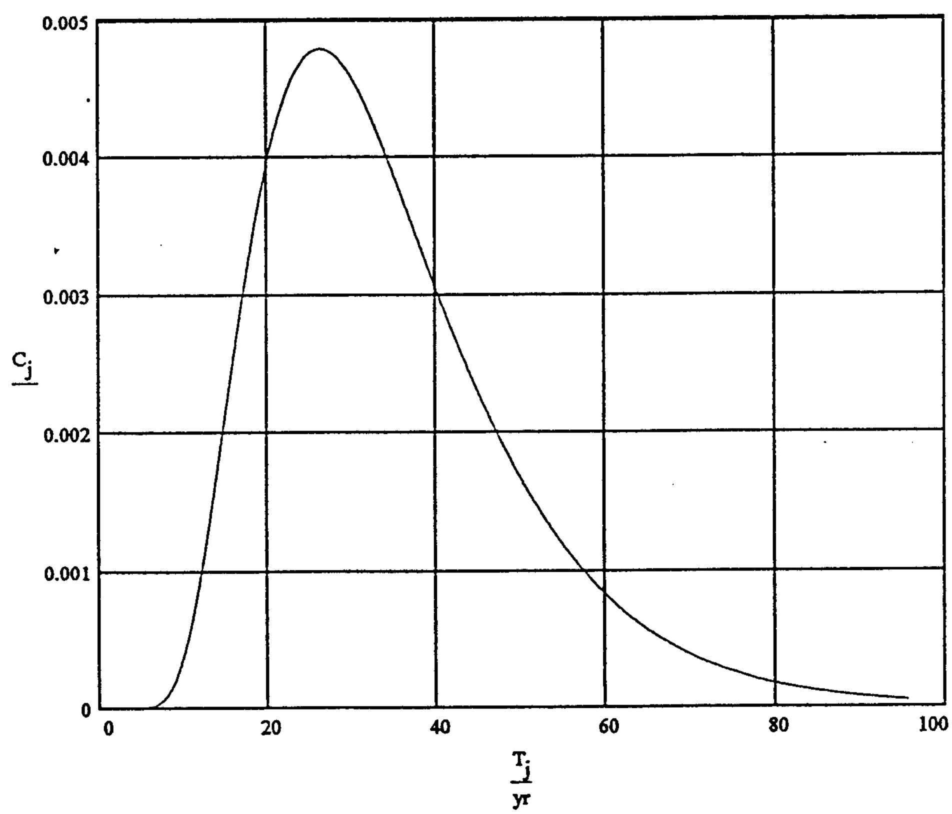
$$x := \delta + d_r$$

$$t_j := \tau + T_j$$

One-dimensional advective-dispersive solute transport solution (Bear, 1979)

$$C_j := \frac{M}{n \cdot \sqrt{4 \cdot \pi \cdot D_L \cdot t_j}} \cdot \exp\left[-\frac{\left(x - v_c \cdot t_j\right)^2}{4 \cdot D_L \cdot t_j}\right]$$

ARRIVAL OF SOLUTE AT BASE BOUNDARY



Peak Concentration and Peak Arrival Time Calculations

The peak arrival time is calculated by setting the time derivative of the 1-D solute transport solution (Bear, 1979) to zero and solving for the time variable.

Initial estimate for arrival of peak at the receptor $\qquad t_a := \frac{d_r}{v_c}$

Given

$$0 \cdot \frac{gm}{liter \cdot day} = \frac{-1}{4} \cdot \frac{M}{\left[n \cdot \left[\sqrt{\pi} \cdot \left[\sqrt{D_L} \cdot t_a^{\left(\frac{3}{2}\right)}\right]\right]\right]} \cdot \exp\left[\frac{-1}{4} \cdot \frac{(x - v_c \cdot t_a)^2}{(D_L \cdot t_a)}\right] \ldots$$

$$+ \frac{1}{2} \cdot \frac{M}{\left[n \cdot \left[\sqrt{\pi} \cdot \left(\sqrt{D_L} \cdot \sqrt{t_a}\right)\right]\right]} \cdot \left[\frac{1}{2} \cdot \frac{(x - v_c \cdot t_a)}{(D_L \cdot t_a)} \cdot v_c + \frac{1}{4} \cdot \frac{(x - v_c \cdot t_a)^2}{\left(D_L \cdot t_a^{2}\right)}\right] \cdot \exp\left[\frac{-1}{4} \cdot \frac{(x - v_c \cdot t_a)^2}{(D_L \cdot t_a)}\right]$$

$$t_p := \mathrm{find}(t_a)$$

Peak arrival time at Base Boundary

$t_{peak} := t_p - \tau \qquad\qquad t_{peak} = 26.223 \cdot yr$

Peak concentration at Base Boundary

$$C_{peak} := \frac{M}{n \cdot \sqrt{4 \cdot \pi \cdot D_L \cdot t_p}} \cdot \exp\left[-\frac{(x - v_c \cdot t_p)^2}{4 \cdot D_L \cdot t_p}\right] \qquad C_{peak} = 0.0048 \cdot \frac{gm}{liter}$$

$ppb := C_{peak} \cdot 10^6$

$ppb = 4.776 \cdot 10^3 \cdot kg \cdot m^{-3}$

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